# Poultry Water Quality Handbook

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Dear Peterson Grower

The protection of our environment and in particular of our region's water quality is of great importance to Peterson Farms. We, as a company, are committed to doing everything we can to insure generations to come have a clean water supply. You, our growers, have made clear your commitment to our environment.

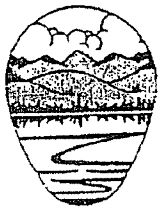
Peterson Farms feels it is important to provide you with the most up-to-date information on water quality; information that will serve as a tool in managing your poultry operation. This book was written by the Poultry Water Quality Consortium for our industry. Using the information in this book will show your commitment and willingness to be stewards of our environment!

Please take the time to review the information in this book. Use it as a resource for making the right choices and following the right management practices in your operation. Peterson Farms will continue to provide you with the most up-to-date information available. Thank you for your time and commitment to this important issue.

Sincerely

Dan Henderson

Dan Henderson
President of Peterson Farms



# Preface to the Second Edition

Air, land, and water — the environment — is more than the place where we live; it is the cornerstone of our quality of life. Every industry, every company, every individual has a stake in the environment.

The poultry industry recognizes the significance of its stake in the environment and the importance of conservation. Protecting the environment from the unintended consequences of production has always been a concern; the phenomenal growth and progress of the industry in recent years have made it a priority. The challenges that come with rapid advancement (e.g., new ways of livestock farming, changing patterns of rural development, water and soil quality) are often too complex to be solved easily or quickly. The challenges are environmental, economic, and social; and they demand cooperation, a free exchange of information, and access to technologies that can help us manage and use poultry by-products as resources, not as wastes requiring disposal.

In pursuit of this goal, the industry and several government agencies created a new venture: the Poultry Water Quality Consortium, to protect natural resources by promoting environmental management. An interagency/industry agreement signed in 1991 and renewed in 1996 formally established the consortium, which includes the following members:

- U.S. Poultry and Egg Association,
- Tennessee Valley Authority,
- U.S. Environmental Protection Agency, and the
- USDA Natural Resources Conservation Service.

The Poultry Water Quality Consortium is a cooperative effort to identify and adopt environmentally prudent uses of poultry by-products. The first edition of the **Poultry Water Quality Handbook** (1994) helped prove the value of teamwork and the successful outcomes that can be expected from the combined efforts of people and organizations, industry and government. No one is excluded from responsibility, not farmers, service providers, company management, or government officials.

The second edition of the handbook reflects the progress made in environmental management since the early 1990s, especially in the development of markets for manure and litter; the diffusion of composting methods; and the emergence of new technologies for mortality, air quality and nutrient management. Growers should find practical help in these pages — but perhaps also a glimpse of how large the community is that shares their goal. Indeed, with so many research projects and field trials now underway, supported by so many people on farms and in university, government, and industry organizations, the industry is in an excellent position to continue its role as an environmental leader..

The Poultry Water Quality Handbook seeks to consolidate information, ideas, and references to enhance water quality. As the adventure continues, the handbook, which the Consortium will continue to format as fact sheets (to encourage their wide distribution, use, and reuse) — will be revised and updated to include new technology and techniques that will ensure the quality of water for everyone.

**U.S. Poultry & Egg Association**

# ACKNOWLEDGMENTS

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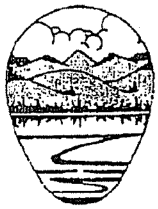

## PREFACE



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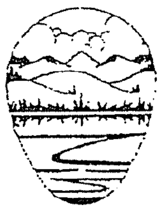

# Introducing the Poultry Industry — Its Environmental Issues and Impacts

In the United States, poultry is a major source of agricultural income. In 1996, according to the National Agricultural Statistics Board, the combined value of production from broilers, eggs, turkeys, and sales of chickens contributed $21.8 billion to the economy — an 18 percent increase over the $18.5 billion reported in 1995.

## U.S. Leadership and International Influence

In 1996, the United States exported 2.3 million metric tons of poultry meat — nearly four times as much as any other nation and twice as much as Brazil and Hong Kong combined, the next largest exporters of poultry meat products. The United States also leads the world in total egg exports. In 1996, the United States exported nearly five times as many eggs as China, the next largest egg exporter, while China exported nearly twice as many eggs as the next largest egg exporters, Denmark, Germany, the Netherlands, and Turkey.

During the same period, inhabitants of the United States consumed 12.1 million metric tons of poultry meat. China, at 11.3 million metric tons, was the second largest consumer of poultry meat. The per capita consumption of poultry meat in the United States reached nearly 45.6 kilograms or 100.76 pounds per annum in the United States in 1996, with demand in Israel nearly keeping constant, and Hong Kong's consumption increasing slightly. Preliminary figures for 1997 show the United States consumed slightly more poultry meat (per capita) than any other nation, as traditionally recorded.

Thus, the United States produces more poultry, consumes more poultry, and exports more poultry than any other nation in the world.

Simultaneously, however, growing populations and rising per capita incomes are leading to increased poultry production in other nations. In fact, the number of chickens reported on a worldwide basis increased 53 percent between 1980 and 1990 — the increase in Asia alone was over 100 percent. Indeed, the technological expertise that underlies the U.S. poultry industry's phenomenal growth can be easily communicated or "transferred" to developing nations, where poultry is important to support growing, more affluent populations. The industry's growth in these nations can also be expected to continue.

## Fueling the Growth

Both genetics and efficiency contribute to the magnitude and value of the U.S. poultry industry. In 1996, for example, broiler production was up 4 percent; egg production, up 2 percent; and the value of turkeys and other chickens also increased. In round numbers, the National Agricultural Statistic Service indicates that U.S. growers raised more than 7.6 billion broilers in 1996; handled 76.1 billion eggs; and marketed 7.17 billion pounds (live weight) of turkey. The number of other chickens (excluding broilers) sold in the United States during 1996 totaled 174 million, a 3-percent decrease from the total sold during 1995 (however, the value of trade in this category increased fractionally despite this decline).

The number of people employed in the industry is difficult to compute, especially if one includes very small operations, and the many off-farm laborers who work in hatcheries, live-bird processing plants, feed mills, and other allied operations serving the industry. Nevertheless, about 70,100 farms reported poultry inventories to the 1992 Census of Agriculture (so that type of farm = poultry); and during the same Census, some 35,000 operations reported poultry-related sales of $1,000 or more under the Standard Industrial Classification (SIC) 025 for poultry and eggs. That is,

- 18,284 farms are categorized as "broilers, fryers and roaster chickens" (SIC 0251);
- 10,636, as "chicken eggs" (SIC 0252);
- 3,361, as "turkey and turkey eggs" (SIC 0253);
- 427, as "poultry hatcheries" (SIC 0254); and
- 2,358, as "poultry and eggs, n.e.c." (SIC 0259).

These numbers establish only the minimum threshold for the size of the industry; however, the estimated and combined value of these markets to each state (based on cash receipts collected in 1996) are shown in Figure 1. The income figures are impressive — as they have been for almost 30 years — and they are expected to increase — probably as much as 5 percent each year into the future.

## Responsible Waste Management — the Environmental Challenge

Such impressive growth is accompanied by an additional yearly legacy. Every increase in poultry production increases the production of manure, used litter, carcasses, and the flow of wastewater from hatchery, egg, layer, and live-bird processing operations. These by-products must be safely disposed of, or used, to ensure that they do not lead to air or water pollution. The challenge for the industry is where and how to use these poultry wastes to benefit the grower and protect the environment.

The rapid growth of the poultry industry internationally only augments the challenge, as does the clustering of poultry operations near food processing plants or large urban markets. The problem is simple to explain, but not so easily solved.

The traditional use for poultry by-products is land application, but land resources are not always sufficient. Expanded or new uses for poultry waste must be sought: for example, poultry waste can and has been used as an ingredient in organic fertilizers, as a horticultural and mushroom growing medium, and as an ingredient in feed products for livestock, dogs, cats, and aquaculture. Indeed, a continuing search for additional uses is part of the challenge of modern production methods.

The poultry industry is committed to protecting water and air quality, the environment and natural resources. Growers in particular share responsibility with other segments of the agricultural community and all citizens for nonpoint source pollution: the pollution that originates from diffuse sources (e.g., agricultural runoff, urban stormwater runoff, and erosion). Some segments of the poultry industry may also contribute to point source pollution: the pollution that issues from a known or direct discharge (e.g., wastewater discharged from the end of a pipe or discharges from processing or treatment plants).

Understanding the complexity of poultry operations can help us address these potential water quality and environmental issues. The industry is separated into hatchery, breeder, broiler-roaster-Cornish game hens (meat types), and turkey, egg, duck, and other poultry and live-bird processing operations. Each of these operations produces dry or liquid waste and dead birds. Recent developments have shifted environmental awareness beyond live-bird processing plants (offal, feathers, and wastewater) to focus on growers. The shift reflects an increasing awareness of how agricultural runoff affects water quality. It also recognizes that the growth of the industry (and its concentration in certain regions) elevates animal waste management to the status of a major problem.

## An Outcome of Modern Production Methods

As any poultry grower knows, the speed, efficiency, and methods used to produce poultry and poultry products have changed drastically during the last 25 years as growers applied mass production techniques to farming operations and brought the benefits of information technology to the farm. As a result, most poultry are grown in confined operations with limited use of water, except for drinking water for the birds. These conditions and changes require each producer to dispose of or use immense quantities of waste.

Any waste, improperly handled, can pollute the environment. In this respect, poultry operations are no different from other human activities, and though each operation is unique, most if not all of the problems can be prevented or solved through proper waste disposal or utilization methods and changes in management style or production techniques. The solutions are not going to be uniform because each operation is different. Still, each one will begin with a model, a technology, or a case history that others can apply and adapt to their own situations.

It is important for growers to know at the beginning of the production cycle (1) how much waste will result from their operations; (2) how they can measure its chemical and physical make up; and (3) how they can account for its potential impacts on water quality, the environment, and human health. In addition, growers must know (4) how and when such impacts will occur, and (5) what measures they can take to prevent these impacts and manage the waste in an environmentally safe manner.

The overriding environmental issue facing growers today is to prevent poultry waste from adversely affecting water and air quality. Potential water pollutants from on-farm poultry operations can be classified as (1) nutrients and salts, (2) organic materials, (3) bacteria, and (4) viruses. Potential air pollutants are dust and volatile organic compounds [gases], and odor, which is primarily a nuisance.

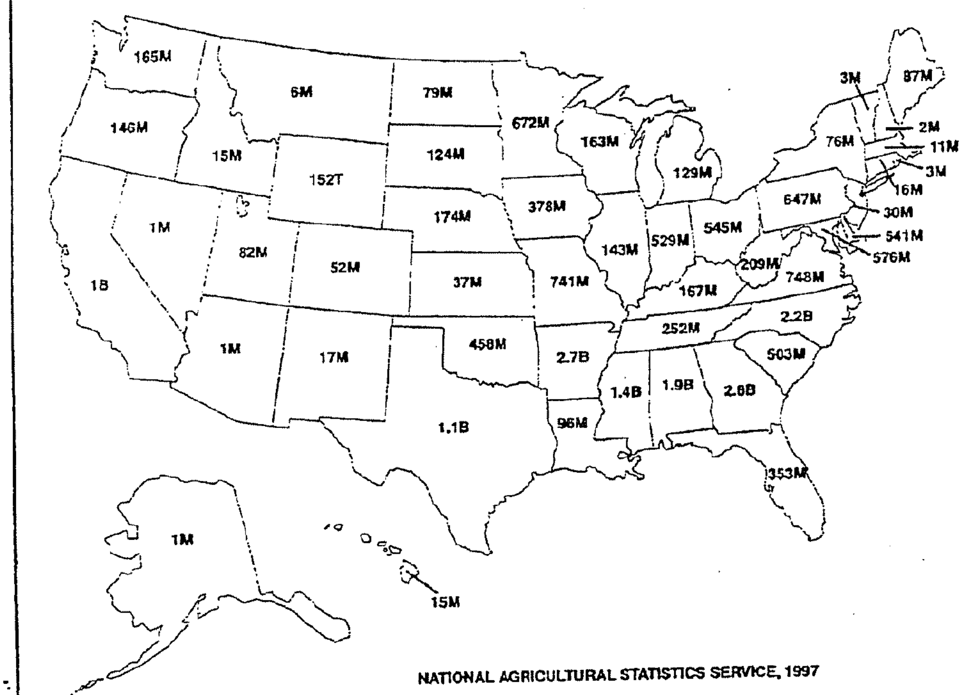


Figure 1.—Poultry cash receipts for 1996 (in dollars).

These on-farm pollutants may originate in manure, litter, or dead birds. How such wastes are disposed of, treated, or managed will directly influence the cleanliness and safety of surface and groundwater resources. Air quality may also be affected by improperly handled poultry by-products. Air and soil are less obvious but no less important media for transporting these pollutants into the environment.

Disposing of spent hens (breeders or table egg layers after their production cycle) and dead birds is an increasing problem. The daily numbers and volume of dead birds will be predicated on the birds' age and weight, the number of birds in the poultry house, and climatic conditions. Acceptable methods of disposal include (1) burial, (2) incineration, (3) composting, and (4) rendering. Burial pits may have severe environmental limitations in areas of porous or fractured soils that would allow leaching of nutrients to groundwater. Incineration has some limitations, including the possibility of air pollution and increased fuel and labor costs.

Many progressive growers are switching to composting or to rendering as preferred solutions from an environmental and economic viewpoint. A grower must choose a method compatible with his or her individual operation and company preference. Dead birds must be treated as a resource that can add value to a grower's operation. Improper methods of disposal are unacceptable and cannot be condoned.

The magnitude of the problem underscores the advantage to be gained from its alternative: namely, that properly managed poultry wastes from manure, litter, dead birds, and wastewater are profitable farm investments. An effective waste management plan provides for the proper collection, storage, handling, and use of poultry waste. Products derived from wastes will reduce chemical fertilizer costs, improve soil quality, and protect water resources, air quality, and human and animal health. Effective waste management will also promote a favorable public attitude toward the industry.

There is not a single best or optimal approach to protect or preserve water quality and the environment. Good waste management practices are essential if the poultry industry is to continue to grow and thrive under today's environmental and societal challenges. The remainder of this handbook relates to poultry waste management (PWM) and poultry mortality management (PMM), and wastewater concerns. Information sheets on these topics provide management "guidance" to help poultry producers make sound environmental decisions; additional fact sheets discuss other environmental issues (OEI) and alternative technologies (AT). Sources of assistance are profiled in the section on Resource Information (RI).

In general, environmental needs and solutions are site specific and regional in nature. Local sources of information, including industry associations, appropriate state agencies, soil and water conservation districts, and the USDA Natural Resources Conservation Service and Cooperative Research Extension, and Education Service offices, should be consulted to ensure that your waste management plan complies with all state and federal regulations.

Producers using this handbook are encouraged to seek assistance from local, state and federal agencies, private consultants, and other professionals on how to implement waste management techniques that protect water quality and the environment. Water quality regulations and permitting requirements vary from state to state and may be more stringent than national regulations.

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## WATER QUALITY ISSUES

Other pages in this handbook contain more detailed information on these subjects. Permission is hereby granted to producers, growers, and associations serving the poultry industry to reproduce this material for further distribution. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone.

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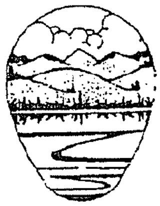

# Protecting the Environment and Water Quality

Protecting natural resources is a major goal of the agricultural community in general, and poultry producers in particular, who care about the environment. The quality of our air, soil, and water resources, the welfare of our animals, and human health issues are important to us and to our children; they are our connection to the future. Water quality is the most important environmental concern of the poultry industry.

Environmental protection begins with awareness. We have to know what's at stake when we read or hear about water quality and conservation, or that high concentrations of nitrates or other contaminants have been found in surface and groundwater. We need to understand how the industry's waste management affects water quality. Above all, we must be able to assess the opportunities we have, as private producers and as an industry, to meet these environmental challenges head on.

Poultry growers and the industry must be concerned about the quality of water that comes into and flows from their farms or plants. The industry's first concerns are those that everyone shares: Does the water we use support our needs? Is it drinkable (potable) and palatable? What does it cost to supply water to our homes and businesses? Would additional costs for water treatment ensure its safety for our use?

## Where the Water Is

Water covers 70 percent of the earth's surface, but only 3 percent of the earth's water is usable by plants, animals, and humans. Usable water exists either as surface water or groundwater. Surface water is the runoff that flows above ground through rivers, streams, and springs until it eventually drains into the sea or oceans. The land area that collects runoff in defined locations is called a watershed, and no matter how far one lives from the water, everyone lives in a watershed (see Fig. 1).

Groundwater is water that percolates through the soil or enters the earth's subsurface through sinkholes, permeable soils, and fractures in rock formations. The underground water formation is known as an aquifer within which the groundwater moves in various directions. Some aquifers are several hundred feet deep while others lie near the surface of the earth. The upper level of shallow aquifers is called the water table. It rises and falls depending on how dry or wet the season is, or how much groundwater is extracted for use.

Water is a renewable resource; therefore, surface and groundwater are constantly being replenished. But water can also be used up faster than it can be renewed or, in the case of groundwater, "recharged." Groundwater recharge is enhanced by limiting runoff. Human activities that speed runoff or add contaminants to surface and groundwater must be controlled. Land sediments, animal wastes, sewage, pesticides, detergents, oils, and grease are some of the human contributions to poor water quality.

## Understanding Water Pollution

Strictly speaking, pure water does not exist. Even rainfall contains gases, dust, and ions acquired from the air. In fact, water (a molecule containing two hydrogen atoms and one oxygen atom) is a solvent; its ability to dissolve substances is essential to plant and animal life. Most of the substances, elements, or com-

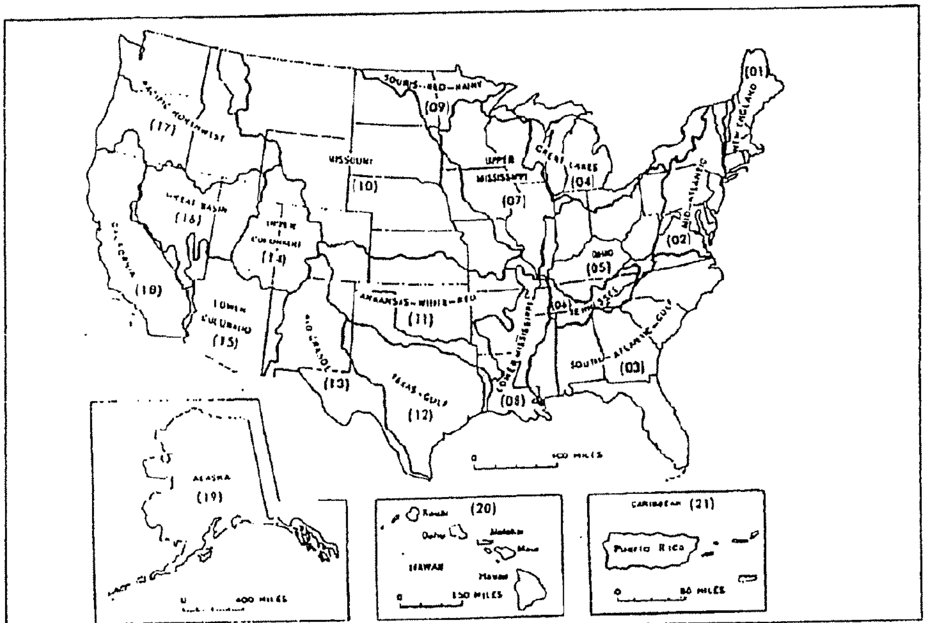


Figure 1.—Water-resources regions of the United States.

pounds that we think of as pollutants are also found naturally in water: nitrogen, phosphorus, potassium, calcium, magnesium, sodium, bicarbonate, chloride, sulfate, carbon dioxide, oxygen, and some heavy metals. But when one or more of these substances is found in excessive amounts, the water's use is impaired and the water may be considered polluted.

Potentially polluting substances, sometimes called dissolved substances or solids, can be organic or inorganic, and they occur in natural interaction among the elements of earth and sky. Their effects include color (or lack of clarity), an offensive taste, and odor. They can be added to the water during industrial, agricultural, silvicultural, land development, or other activities that serve human needs and pleasures. In the poultry industry, for example, components of manure, dead birds, and wastewater include nutrients that may be released to water through direct discharge, excessive runoff from the land, or leaching through the soil.

We expect, then, to find some dissolved substances in water; however, water's properties are degraded — its quality impaired — if it contains chemical, biological, physical, or radiological substances in sufficient quantity to restrict its use. Water quality standards defined by the U.S. Environmental Protection Agency (EPA) identify what substances must not appear in water and at what concentrations other substances may be permissible under certain conditions. Tests or analyses that must be performed on drinking water, surface, and groundwater to assess water quality illustrate the complexity of the issue.

> This information sheet introduces the topic of water quality. Poultry growers and others should always check with local health agencies or state departments of environmental protection or similar agencies to ensure that they have access to current water quality criteria and standards applicable to their location. Water quality criteria are published in the Federal Register as they are developed.

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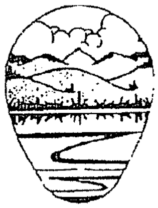

# What Is Water Quality?

Public domestic water supplies are regularly tested or analyzed for pollutants or contaminants. The results can be obtained from local health departments or appropriate state agencies. Private water supplies or wells should also be analyzed.

The most common tests for water quality analyze (1) pH (the level of hydrogen ions in the water), (2) total alkalinity, (3) total hardness, (4) salts, (5) chlorine, (6) dissolved oxygen, (7) metals, and (8) pathogens. Sometimes water needs to be tested for heavy metals, such as copper, lead, mercury, or zinc; or for toxins, such as DDT or atrazine. In some areas of the country, tests for radiological contaminants may be needed.

## Chemical Properties

The following parameters are of importance to the poultry industry.

- The measure of pH in water determines its acidic or alkaline quality on a relative scale. (For example, in a solution of hydrochloric acid, the pH may be 3; for sodium hydroxide, it may be 12.) In water, on a scale from 0 to 14, a pH measure of 7 is neutral; for drinking water for humans and animals, the desirable measure of pH is 6.5 to 8.

- The total alkalinity of water is a measure of its capacity to neutralize acidity, which is usually expressed in milligrams per liter of calcium carbonate (mg/L of $CaCO_3$). Natural waters may have less than 50 or as many as 500 mg/L of $CaCO_3$. These variations may be affected by the rocks and soils that the water passes through. The alkalinity varies with pH and hardness, but sudden fluctuations may indicate a contaminant.

- Water also contains total dissolved solids (TDS) and minerals. TDS represent the soluble mineral or salt content of water, especially calcium, magnesium, sodium, chloride, sulfate, bicarbonate, and silica. These substances, if excessive, will affect machinery and industrial processes (by clogging pipes for example, or corroding switches), and their presence in water is frequently associated with discharge from industrial operations.

  TDS also affect the germination and growth of plants and the palatability of drinking water, though some minerals are desirable for their beneficial properties. Drinking water should not have more than 500 mg/L of TDS while irrigation waters may have up to 1,500 mg/L of soluble minerals.

  *Hard waters* contain so much calcium and magnesium that it is difficult to make soaps lather. When heated, hard water forms the scale or deposits that we see on cooking utensils and water pipes. Water softening solves the hard water problem but may increase the amount of sodium in the water — a possible danger to people on low sodium diets. Sodium in drinking water should be limited to about 20 mg/L.

  *Total iron* (suspended and dissolved) causes problems in water if it exceeds 0.3 mg/L. High iron levels impart a reddish brown color to water or a bad taste to cooked foods and may restrict growth in turkeys.

  *Chlorides* in water should not exceed 250 mg/L; otherwise, the water may have a salty taste. Excessive chloride levels may also indicate pollution from sewage or other sources.

*Sulfates*, which should not exceed 250 mg/L, are caused by the leaching of natural deposits of magnesium sulfate (Epsom salts) or sodium sulfate (Glauber's salt). These salts are undesirable because of their laxative effects.

*Nitrates* ($NO_3$-) and nitrites ($NO_2$-) pose health problems to animals and humans, including poultry. Their presence in surface or groundwater in large amounts may indicate septic tank failures, overfertilized fields, or other problems. Nitrate nitrogen levels in drinking water should not exceed 10 mg/L; and nitrites, which convert to nitrates, should not exceed 1 mg/L.

- Chlorine gas and other chlorine compounds are powerful disinfectants and oxidizing agents. Chlorine should be limited in drinking water to no more than 0.05 mg/L; however, there must be a small chlorine residual in public drinking water systems to assure that the water is disinfected.

- Dissolved oxygen (DO), which is vital for aquatic life, can be a key test for water pollution. At DO levels below 3 mg/L, fish may become stressed or die. Generally, in unimpaired waters, dissolved oxygen ranges from 7 to 14 mg/L. However, DO levels approaching 14 mg/L on sunny days may indicate high density algae growth and possible nutrient enrichment (pollution).

Usually, among these parameters, only pH, total iron, DO, and nitrates/nitrites have reference to poultry. Nevertheless, careful and complete monitoring of private water supplies and wells is a must because they provide drinking water for home and poultry operations. When the chemical properties of water exceed acceptable limits for intended uses, water quality is impaired.

### Biological Properties

Private water supplies should also be tested once or twice a year for any sign of coliform bacteria. The test for fecal coliform bacteria can differentiate between the bacteria found in soils and plants and the bacteria found in warm-blooded animals. Common symptoms of coliform bacteria in humans are intestinal bloating and diarrhea.

Other bacteriological tests can identify many kinds and numbers of bacteria in water, but they do not separate harmful and harmless bacteria. Tests for Fecal Streptococci, Shigella, Salmonella, Staphylococci, and other bacteria may be necessary under certain circumstances. These tests are specific, time-consuming, and expensive. They isolate bacteria that cause typhoid fever, eye and ear infections, dysentery, boils, or other skin diseases. There are also tests for viruses, protozoa, and parasites.

In surface waters, aquatic vegetation and microscopic animal and plant life may be stimulated or retarded by various water quality factors — pH, nutrients (nitrogen and phosphorus), and turbidity, among others. But growth and decay cycles may have side effects that adversely affect water quality. Even helpful substances can become harmful in overabundance; for example, organic nitrogen in animal wastes and soils can cause "nutrient loading," which results in low DO levels and eutrophication (i.e., an overly productive waterbody.)

### Physical Properties

Physical characteristics of water include turbidity, color, taste, odor, and temperature. The presence of foam is an indicator of dissolved organic substances, perhaps raw sewage. Suspended particles may cloud the water, and dissolved substances may alter its odor or taste. Turbidity or cloudy water may indicate the presence of suspended sediments, which reduce light penetration. Color affects quality and can be aesthetically displeasing. Taste and odors can result from dissolved metals, gases, organic materials, or chemicals.

### Radiological Properties

Some radioactivity in water, food, and air is natural. However, if higher levels than usual are suspected, the appropriate state agencies should be notified.

### Summary

Without efficient management of poultry waste and dead birds, poultry operations could become a source of excess nutrients, disease-causing bacteria or viruses, and dissolved substances in our nation's surface and groundwater supplies. Proper waste management will enhance the quality of water for everyone.

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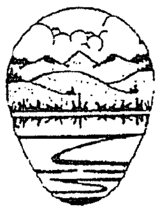

# Poultry Production and Water Quality

Every year, environmental issues seem to gain emphasis nationally and internationally as the importance of a cleaner environment and respect for pollution prevention practices receive increasing public support. The matter is most pressing to livestock and poultry producers because as environmental sophistication grows so does the focus on nonpoint source pollution. What is more, this deeper environmental sensitivity has occurred simultaneously with an extraordinary increase in the size of the poultry industry and its concentration in certain regions near processing and packing plants. The potential for adverse environmental impact appears greater as a result of the industry's trend to grow ever larger numbers of birds on smaller areas of land.

## Understanding Animal Wastes and the Environment

Good waste management practices are essential for preventing the transport of sediments, nutrients, and bacteria into groundwater, rivers, and streams — that is, to prevent pollution — and to protect agricultural resources. The latter aspect of waste management ensures that growers will get the best return on their investments since animal waste is also a valuable resource, a collection of by-products that can be reclaimed for other uses.

The term "poultry waste" generally refers to manure: the feces and uric acid excreted by the growing birds; "litter," on the other hand, refers to manure and used bedding materials. Other wastes associated with poultry production include washwater, storm (and muddy) water runoff, and the carcasses of dead birds and spent hens. Processing wastes include other rendering and lagoon residuals.

These same materials, however, contain (1) valuable nutrients that can reduce the need for commercial fertilizers and increase plant yield; and (2) organic matter that can improve soil quality and extend its ability to hold water. Little wonder, then, that what happens to these by-products can be good or bad for the industry and for the environment.

On the one hand, poultry wastes can do a lot of good. They can be used as fertilizer, soil enhancers, cattle feed, or energy. Poultry producers can add value to these products — and prevent them from contaminating surface and groundwater — by using proven, acceptable methods of collection, storage and handling, treatment, disposal, and management. All such beneficial uses depend on proper management. Without such management, the value of the waste will decline rapidly, even as its potential for adversely affecting the environment and water quality steadily rises.

## Pollution Is Not Inevitable

Poultry growers, whether their operation is consolidated or diversified need not produce any pollution outside the system. Pollution occurs only when litter is mismanaged — for example, when it is land applied in quantities that exceed plant needs, or when the ground is wet or frozen. As a result of such applications, potentially contaminating substances become "available" to the environment. If they also become "detached" from the site, for example, by being adsorbed to sediments or dissolved in water, they can be "transported" off site. Transport occurs when contaminants in the animal waste (the unused nutrients, bacteria or other elements in the litter) are released to surface drainage or infiltrate beneath the soil surface in groundwater recharge areas.

To control and prevent pollution, poultry growers need to understand how the value of such by-products can be enhanced and maintained. The value in poultry by-products and their potential to cause either point or nonpoint source pollution have the same origin. That is, the waste and dead birds contain nutrients and salts, suspended materials, the various products of biological reactions, and microorganisms. These elements can be beneficial to the grower, other farmers, the environment, or they can be harmful.

## Nutrients and Salts

Poultry manure is a valuable nutrient for grain and fiber crops, forage crops, fruits, and vegetables. However, if manure, litter, dead birds (as compost or as buried carcasses), and/or wastewater are not properly protected and utilized, water contamination can occur from the release of excess nitrogen and phosphorus into the environment.

Nitrogen is an essential plant nutrient but, in excess, it can be harmful. High concentrations of nitrate in drinking water can affect human health, especially in infants and children. Ammonia in small quantities is toxic to fish and aquatic organisms; and high concentrations of nitrate in drinking water can also have significant effects on young chickens.

When nitrogen and phosphorus concentrations in waterbodies rise too high, algae and rooted aquatic plants take over, prematurely aging and choking the waterbody and creating undesirable conditions — odors, offensive taste, and discoloration — all of which can make the water unfit for consumption or recreational and aesthetic use. Further, these eutrophic conditions can kill fish, clog water treatment plant filters, and lead to the growth of blue-green algae, a species that can be fatal to livestock.

Because nitrate-nitrogen is highly mobile, it can leach into groundwater and flow with stormwater runoff into surface waters. If too much poultry manure and litter are used as fertilizer, nitrogen and phosphorus concentrations in nearby waters are likely to be high. Soil erosion also increases the amount of phosphorus in surface waters. Excessive phosphorus in soil, above 800 mg/L, may become soluble and move into groundwater. Phosphorus concentrations may vary, depending on the type of soil and its organic content.

Calcium and sodium salts are added to poultry feeds to help the birds maintain chemical balance and nutrition. Excess salts pass through the animals and are eliminated in manure. Sometimes, when the waste accumulates, the salts leach into groundwater and enter surface water through unprotected runoff. There they alter the water's taste or harm freshwater plants and animals.

## Suspended Materials

When suspended matter from poultry wastes reach surface water, the waterbody not only looks unattractive — the quality of the water invariably suffers. The suspended material reduces the penetration of sunlight and therefore slows the production of oxygen. The result is an oxygen demand that reduces the levels of dissolved oxygen in the water. It also clogs fish gills, makes it difficult for sight-feeding fish to find food, and settles over fish spawning areas.

## Products of Biological Reactions

In a natural environment, the breakdown of organic matter, such as poultry waste, is a function of complex, interrelated, and mixed biological populations. All substances of animal or vegetable origin contain carbon and are, therefore, organic. Organic matter is converted to simple compounds by naturally occurring microorganisms. These simple compounds may be other forms of organic matter or they may be nonorganic compounds or gases, such as nitrates, orthophosphates, ammonia, and hydrogen sulfide. A biological reaction occurs when manure or other organic matter is added to water and anaerobic or aerobic organisms begin the decaying process. Aerobic bacteria (oxygen requiring organisms) consume free oxygen and produce carbon dioxide gas. Under anaerobic conditions (without oxygen), methane, amines, and sulfides are produced.

## Microorganisms

Desirable and undesirable microorganisms live in our environment. Animal waste is a potential source of some 150 disease-causing organisms or pathogens. These organisms include bacteria, viruses, fungi, protozoa, and parasites. Examples of undesirable microorganisms include Salmonella, Cryptosporidium, Giradia, Listeria, coliform, New Castle (virus), ringworm, coccidiosis, and Ascaris.

When found in water or wastes, these pathogens pose significant threats to humans and other animals. They can infect humans and animals through drinking water, contact with the skin, or consumption of fish or other aquatic animals. Most pathogens die relatively quickly. However, under the right conditions, they may live long enough to cause problems. They may persist longer in groundwater than in surface water.

Producers can prevent poultry by-products or waste from contaminating water. However, environmental needs and solutions are site specific and regional in nature. In some cases, state regulations and permitting requirements may be more stringent than federal regulations. Therefore, local sources of information, including industry associations, state departments of environmental protection and public health, and USDA Natural Resources Conservation Service and Cooperative State Research, Extension, and Education Service offices should be consulted about poultry waste or by-products that affect water quality.

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Other pages in this handbook contain more detailed information on these subjects. Permission is hereby granted to producers, growers, and associations serving the poultry industry to reproduce this material for further distribution. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone.

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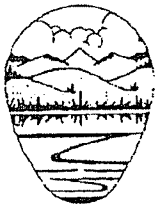

# Understanding Water Quality Regulations

As the poultry industry grows, so does concern for water quality, conservation, and environmental management. Growers have individual and civic reasons for caring: they are responsible with other human beings for the earth's environment, and they realize that they, their families and neighbors, and those who live in connecting watersheds, distant cities, even other countries — ultimately breathe the same air and drink the same water.

Pollution is intolerable whether it occurs on privately owned land and water, or travels many miles downstream or over mountains to other destinations. The arithmetic is simple: good environmental stewardship reduces the cost of water pollution, saves natural resources, and makes good neighbors.

## Federal and State Statutes

Federal water quality laws and regulations administered by the U.S. Environmental Protection Agency (i.e., Clean Water Act, Safe Drinking Water Act, National Pollution Discharge Elimination System [NPDES] Permits) and the laws of each state make it illegal to discharge wastes of any kind to waters of the United States. That is, poultry waste cannot be collected, stored, or applied anywhere or in any manner that would likely result in water pollution.

In rare instances, the effect of combined federal and state regulations appears to create double jeopardy. Such situations (though they can be misused by the media or exploited to create controversy) can usually be swiftly resolved; however, compliance with environmental regulations requires careful planning and management. A rule of thumb is simply to assess one's whole operation from time to time (e.g., Farm•A•Syst assessments are self-administered, voluntary, and confidential) to ensure that no conditions arise on the farm that would put the grower at risk of violating water quality laws.

Because regulations differ and each state has its own enforcement procedures, poultry growers are well-advised to check with state and local agencies before production begins or systems change. Often the state's requirements are more stringent than federal requirements; however, growers in coastal zones may be subject to additional federal statutes as a result of the Coastal Zone Act Reauthorization Amendments of 1990. Industry organizations, agricultural research institutions, private and government agencies can help growers know, understand, and comply with the regulations in their area.

## Point and Nonpoint Source Pollution

For management purposes, water pollution sources are divided into two groups or types. *Point source* pollution comes from a discrete man-made conveyance, such as a pipe, lagoon, ditch, or storage tank. *Nonpoint sources* of pollution are dispersed, harder to pinpoint, and cumulative. They include land uses or human activities that are potentially significant because they are common and widespread. Agriculture, mining, forestry, highway and other construction, septic tank, fieldline, and other waste disposal systems, and urban runoff are examples of potential nonpoint source pollution.

Some activities are regulated as point and nonpoint sources of pollution. For example, industrial or municipal utilities may operate treatment plants, which are point sources of pollution, but they may also be responsible to prevent further contamination from, or of stormwater runoff, a nonpoint source of water pollution. Similarly, some livestock facilities may be regulated as point sources when they are collecting, storing or conveying facility wastewater and runoff; but once the manure or litter has been applied to the land, it is managed as a nonpoint source. Poultry growers must know how to manage point and nonpoint sources.

## General Guidelines

Since the Clean Water Act was passed in 1972, concentrated animal feeding operations (CAFOs), including some large poultry houses, have been regulated as point sources of pollution. Federal law which the states administer through the National Pollutant Discharge Elimination System (NPDES) program forbids point source discharges, that is, the discharge of any pollutant or contaminant to "waters of the United States."

Thus, CAFOs, like other point sources, must obtain an operating permit which prohibits discharge except from lagoons during storm events greater than 24-hour, 25-year storms. The permit also specifies best management practices to protect surface water, including diverting off-site drainage around the facilities and designing appropriate storage facilities for manure and process-generated wastewater. Adequate runoff storage must be included in the design; lagoons or holding ponds must be sized to withstand a 25-year, 24-hour duration storm.

## Nonpoint Source Prevention Practices

The extent of nonpoint sources has been more fully realized in the last decade, but they are usually assessed locally on a stream-by-stream basis and controlled by conservation or "best management practices" (BMPs). BMPs are routine activities that can be incorporated in animal and crop farming to conserve natural resources and protect air, soil, and water quality. They are structures or activities that reduce the potentially harmful effects of agricultural production.

## State and local Guidelines

Most states now require (1) permits for the operation and construction of confined animal facilities whether current or planned, if the facility uses a liquid waste management system; and (2) that all livestock farmers plan their waste management and disposal system, especially as it concerns land applications. Whether these plans are written, kept on file, or simply in evidence on site, may depend on other circumstances.

The conditions pertaining to permits are not uniform across the states, but they usually provide specific guidance for operations at, under, or exceeding a certain size; establish setback distances for grower houses, lagoons, and waste management structures (to protect water and air quality and to limit any nuisances that might impinge on nearby homes or public buildings, such as schools and churches); buffer zones; and design specifications for new construction.

Land application requirements generally establish when and where applications can be permitted; for example, only at approved rates, and with nutrient management planning; not on frozen ground or when rain is expected on slopes greater than 15 percent, or on setbacks from public buildings and property lines. Typical setback distances for land applications are 100 feet from streams or ponds, sinkholes, wells, and water supplies, and 50 feet from any water lines or known agricultural drains.

## Getting Help

A system of standard operating procedures or practices developed in accord with, or as part of, a "resource management plan, or "animal waste management system" recommended by the USDA Natural Resources Conservation Service (NRCS), will generally meet state and local requirements. The NRCS offers technical assistance to growers and often works with local soil and water conservation districts and state and local agencies to help farmers write suitable plans.

Such guidance augments the grower's own engineering and technical resources and makes it easier to adapt national conservation practices to regional conditions. It may also be possible that growers are eligible for cost-sharing. The USDA has used cost-share programs to encourage conservation over many years. Similar programs may now exist or are being developed.

The NRCS guidelines can be found in the Agricultural Waste Management Field Handbook (AWMFH) or Field Office Technical Guides (FOTG) which are reviewed and supplemented as needed. Supplements to the National Handbook and specifications prepared by the states are reviewed in NRCS field offices to ensure the consistency of new and emerging technologies and rules. The U.S. Environmental Protection Agency and the Cooperative Extension Service have also prepared guidance documents applying conservation practices.

## Changing Attitudes

In the United States, regulations to control nonpoint source pollution are not the only driving force behind changing attitudes. Voluntary programs, public education, and financial incentives are more in tune with traditional values. Growers want to protect the environment, increase their efficiency, and enjoy a good public image.

Animal waste management practices can increase their return on investment and protect natural resources, especially if one's objectives are as clear as this simple waste management formula:

- prevent the generation of wastes where possible;
- recycle wastes that cannot be prevented;
- pretreat wastes to eliminate possible contaminants; and
- dispose of unusable wastes properly as a last resort.

Management commitment and awareness, scientific research and common sense, and in some cases, new installations and equipment are needed to protect the availability and quantity of our natural resources. The scope of the problem is global, national, and industrywide; cooperation among agencies, associations, and individuals speeds the development of technology and its transfer, and creates a participatory environment that encourages the search for solutions and fosters attitude changes.

## Compliance Issues

Water quality legislation has teeth. Section 309 of the Clean Water Act establishes criminal penalties for failure to comply with the regulations. The threat of prosecution can be a first step in forcing compliance; the charges can range from minor infringements or negligent actions (lightly punished) to more serious charges of conscious violations and knowing endangerment. Knowing and willful endangerment and outright falsification are the most serious charges.

In short, point source wastewaters that leave a poultry house or plant must comply with the national effluent levels. A pretreatment program may be necessary. Some poultry operations have discovered that running their own pretreatment plants, though expensive, can be more efficient than other methods of compliance.

The U.S. Environmental Protection Agency now uses audits to determine how and why publicly owned treatment works are not in compliance. Recent regulations (in 40 C.F.R. Part 403) concern pretreatment:

- Pollutants that would interfere with the operation of the publicly owned treatment works or cause fire or explosive hazards are not permitted.
- No pH levels lower than 5.0 are allowed.
- Solid or viscous pollutants are monitored.
- High levels of biological oxygen demanding substances (BOD) are regulated as are oils, grease, and toxic gases.

The poultry industry should, therefore, take an active part in pretreatment programs.

> Federal regulations are administered in most cases by the states, whose regulations and permitting requirements vary and may be more stringent than national regulations. Please consult local sources of information, including industry associations, state departments of environmental protection and public health, and USDA Natural Resources Conservation Service and Cooperative State Research, Extension, and Education Service offices, to ensure that your waste management activities comply with all regulations and ordinances.

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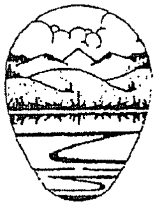

# Drinking Water Quality — Protecting Your Birds' Health and Performance

Drinking water for poultry and other animals, ourselves included, is an important dietary requirement — and an easy one to take for granted. Under normal conditions, poultry will consume twice as much water as food — two pounds of water (about a quart) for each pound of food, though this amount will vary seasonally and with the bird's age.

Water is not only a nutrient; it also softens food and carries it through the body, helps digestion and absorption, and cools the body as it evaporates through the bird's lungs and air sacs. Water helps animals remove waste, lubricates their joints, and helps maintain body temperatures. Further, water is used to deliver vitamins and vaccines (though vitamin dietary supplements are probably only needed during stress conditions). Water is a major component in blood and a necessary medium for many chemical reactions that help form meat and eggs.

Poor water quality, on the other hand, can retard growth, curtail egg production, or produce lower egg quality, even before it is readily apparent. In many cases, however, growers merely assume the security and quality of their water supply. This assumption, though it obviously fits our traditional experience, leaves the water untested until or unless it adversely affects the flock's health and performance.

Growers who carefully monitor feed consumption, egg production, temperature, ventilation, light intensity, and mortality as factors related to optimal production should pay similar attention to water quality and to how much water their birds actually consume. It is important to have the water tested from time to time.

Water varies greatly in its quality and potential for contamination — even from wells in the same county — and the quality can be altered by extremes in its content, such as pH, bacteria, hardness and varying amounts of naturally occurring elements. Some pollutants may have little effect on the birds. It is always possible, however, that factors that do not affect the birds in one environment — for example, poultry are relatively tolerant to nitrate — will in another. Thus, nitrate has been known to affect the birds' performance when it is present in water along with other contaminants such as bacteria. In such cases, when the proper treatment of water is begun, or changes are made in the source of the birds' drinking water, their health and performance quickly returns to its normal levels.

Similar single or aggregated effects have been discovered in the birds' reactions to other naturally occurring elements. Thus, feed conversion, for example, has been positively correlated to the presence of sulfate and copper concentrations in the water, and livability with potassium, chloride, and calcium. Body weight is positively influenced by drinking water hardness and dissolved oxygen, and negatively influenced by total bacteria and pH less than or equal to 6.0. Acidity (which is corrosive in piping) is usually maintained at normal levels in drinking water supplies, but some growers acidify water to help prevent bacteria.

Drinking water standards have been established for human consumption, but not for birds. It is safe to say, however, that a consistent source of high quality water is essential for the optimum performance that today's market conditions require. The following table can be used to determine poultry drinking water quality.

Table 1.—Drinking Water Quality Standards for Poultry.

| CONTAMINANTS | AVERAGE LEVELS | MAXIMUM ACCEPTABLE | REMARKS |
|---|---|---|---|
| BACTERIA | | | |
| Total bacteria | 0/mL | 100/mL | 0/mL is desirable |
| Coliform bacteria | 0/mL | 50/mL | 0/mL is desirable |
| ACIDITY/HARDNESS | | | |
| pH | 6.8–7.5 | 6.8–8.0 | < 6.0 is undesirable; < 6.3 may degrade performance. |
| Total Hardness | 60–180 ppm | 110 ppm | < 60 is unusually soft; > 180 is very hard. |
| NITROGEN COMPOUNDS | | | |
| Nitrate ($NO_3$) | 10 mg/L ($NO_3$-N) | 25 mg/L | Levels of nitrate from 3 to 20 mg/L may affect performance. |
| Nitrite ($NO_2$) | 0.4 mg/L ($NO_2$-N) | 4 mg/L | — |
| NATURAL CHEMICALS | | | |
| Calcium (Ca) | 60 mg/L | — | — |
| Chloride (Cl) | 14 mg/L | 250 mg/L | Even 14 mg/L may be detrimental if sodium level is higher than 50 mg/L. |
| Copper (Cu) | 0.002 mg/L | 0.6 mg/L | Higher levels of copper produce bitter flavor. |
| Iron (Fe) | 0.2 mg/L | 0.3 mg/L | Higher levels of iron produce bad odor and taste. |
| Lead (Pb) | — | 0.02 mg/L | Higher levels of lead are toxic. |
| Magnesium (Mg) | 14 mg/L | 125 mg/L | Higher levels of magnesium have laxative effect. Levels > 50 mg/L may affect performance if sulfate level is high. |
| Sodium (Na) | 32 mg/L | 50 mg/L | > 50 mg/L of sodium may affect performance if sulfate or chloride is high. |
| Sulfate ($SO_4$) | 32 mg/L | 250 mg/L | Higher levels of sulfate have laxative effect. Levels >50 mg/L may affect performance if magnesium and chloride are high. |
| Zinc (Zn) | — | 1.5 mg/L | Higher levels of zinc are toxic. |

Source: Adapted from Carter and Sneed, 1987.

## Observe the Birds' Drinking Habits

Water temperature and taste are important components of water quality. They make the water appealing (thereby ensuring that animals will not neglect to drink in sufficient amounts); and they also indicate other problems: the presence of contaminants (e.g., disease-causing organisms or toxic metals); an acidic imbalance, or too much sodium. While several elements can cause poor water quality, the interaction between elements is, as previously noted, more significant in water quality problems than the simple fact of their presence.

Thus, producers should be concerned if their birds' drinking water contains any of the following elements:

- high concentrations of bacteria, particularly coliforms;
- dissolved solids — organic, inorganic, or toxic elements;
- turbidity (i.e., the presence of material in suspension rather than in solution in the water); and
- unpleasant physical characteristics, such as bitter, hard, odiferous, cloudy (or tinted) conditions.

The presence of any of these characteristics is sufficient to warrant investigation and perhaps an improvement or change in the water supply to protect the flock's health, longevity, and production. The following elements, however, should be of particular concern:

- the presence of nutrients, especially nitrate and nitrite;
- high concentrations of sodium, chloride, and hydrogen sulfide (sulfur water);
- excess levels of iron and manganese;
- toxic elements, such as lead, selenium and arsenic;
- microbial contamination; and
- industrial chemicals or toxins.

Nevertheless, the most telling effects of poor water quality are generally caused by the presence of bacteria or minerals. Thus, high concentrations of bacteria or toxic elements in the water affect the normal physiological processes of the animal, resulting in inferior performance. High concentrations of minerals may have less effect on the animals unless or until they clog the water system, depriving the animals of water.

Qualities to look for include turbidity, taste, odor and color. Turbidity results from materials in suspension, for example, silt; clay, algae or organic matter. Turbid waters are unpalatable, and they clog the delivery system. Water should not taste bitter, sweet, salty, or sour, since such impressions are usually the effect of salts. Bitter tasting water may be contaminated by iron and manganese sulfates. Iron gives the water a reddish or brownish color; copper tends to turn the water bluish. On the other hand, the water may be clear without being safe. The presence of total dissolved solids is not visible in "clear" water.

Sulfur water smells too much like rotten eggs arising from the presence of hydrogen sulfide; hydrogen sulfide and iron will create the condition known as "black water." Since hydrogen sulfide is caused by bacteria, chlorination can help solve the problem. Sulfate is a laxative and therefore a cause of wet litter in poultry houses. Sulfate generally does not cause a similar odor in water.

## Practice Good Maintenance and Sample the Water Supply

Baby chicks are 85 percent water, adults are 55 to 60 percent water and eggs are 66 percent water. Even a 10 percent loss of water can cause serious physiological disorders and a 20 percent loss can lead to death. Thus, maintaining a quality drinking water supply in each poultry house is important, and checking the drinkers for proper functioning should be a normal part of an operator's daily routine. In fact, water cleanliness techniques should evolve each time an equipment line is upgraded.

Bell-type drinkers, for example, can have a high level of bacteria, but growers can use chlorination to solve this problem provided that they discontinue chlorination in cases of heat stress. And, because chlorine also kills viruses, and vaccines, powdered milk should be run through the system ahead of vaccines. Discontinue water treatment 72 hours before water vaccination.

Some growers are using intermittent watering programs to help save water and improve the litter (by keeping it drier). This procedure provides plenty of water but prevents overconsumption and spillage. It is not generally recommended in summer or with nipple and cup waterers. The attempt to conserve water and litter by cutting back on the amount of water in the waterers, while yet allowing the birds to drink at any time is not as safe as the intermittent watering regime.

To test your water: collect samples either at the well source or at the point of entry into the house, use a clean quart plastic bottle and transport the sample to a diagnostic lab. To test the bacterial levels of the water, flame the faucet with a propane torch, then run a small amount of water to cool the faucet. Collect the sample in a sterile container, and if possible avoid taking the sample in the broiler house in which birds are present.

## Consider the Experience of Other Producers

Several demonstration projects have been done to assess the effects of poor water quality on poultry production. While the data are not conclusive, they do show the correlation between poor water quality and inferior production.

A field study conducted in Canada sampled the water supply of 33 farms (involving layer, broiler, and turkey farms). The producers were surveyed regarding any health or other problems they may have experienced in the month prior to the sampling. The parameters tested included carbonates, bicarbonates, pH, chloride, fluoride, nitrate, nitrite, sulfate, magnesium, calcium, sodium, potassium, and phosphate. The analysis revealed several instances in which the producer's problems directly correlated with water quality impairments.

On an egg producing farm, for example, the producer reported a high incidence of diarrhea among the flock and severe problems with the egg shells. About 15 percent of the eggs had pin-sized holes in their shells. The water quality on this farm had higher levels of carbonates, bicarbonates, sodium, chloride, and pH than any other farm participating in the survey.

Research by R.E. Waggoner profiled in a January 1987 issue of *Poultry Digest* has also shown that changes in water quality can affect the birds' performance. A demonstration conducted at two similar broiler houses — one performing well, the other not performing well — successfully linked the different outcomes to differences in the water supply. When the water supply was tested, the water quality was "good" at house number 1 (as was its performance); but the water at house number 2 (with unsatisfactory performance) had high concentrations of sodium and bacterial contamination.

On the same farm, another two broiler houses were connected to different water sources. One was fed from an old well, the other from a well that had only recently been drilled. When birds raised in the house connected to the new well did not thrive as expected, this house was reconnected to the old well, and its performance improved. Thereafter, high concentrations of sodium and sulfate were found in the drilled well.

Simple water sanitation procedures can protect poultry's drinking water from contamination. Producers have different opinions about which cleaning technique is most effective, but no one disputes its necessity. Some producers use cleaning agents to remove scale and slime, to tie up minerals in the water, and flush medications from the lines. These measures are followed by sanitizers to kill bacteria and algae.

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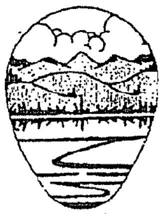

# Environmental Impacts of Poultry Waste

Poultry raised for commercial purposes produce large amounts of manure which — unlike the manure of free range or pastured animals — is a collectible resource. It contains valuable plant nutrients and other chemicals that, if properly managed, can be returned to the land or processed for other uses. Therefore, anyone planning to undertake a confined animal feeding operation must give serious attention to the proper handling of manure and other waste products.

Factors influencing the choice of animal waste management systems begin with the type and size of the operation being contemplated, the grower's management skills and inclinations, the local environment, federal and state laws and regulations, and the effect of the proposed waste management plan on the operation's economic forecast. The importance of the choice increases in proportion to the volume and potential value of the residual materials.

## For Voluntary Action

The National Farm Assessment Program (Farm*A*Syst) expanded from a 1991 pilot project in Wisconsin and Minnesota. It is funded by the USDA Cooperative State Research, Education, and Extension Service, the USDA Natural Resources Conservation Service and the U.S. Environmental Protection Agency.

A Farm*A*Syst checklist provides a simple way to identify (1) where a grower's management actions and environmental concerns intersect; (2) the degree to which current practices may be putting these vulnerable points at risk; and (3) strategic actions one can take to correct problems and reduce risk. The checklist, or self-assessment, is comprehensive but not lengthy; and it is completely private. Other Farm*A*Syst program materials explain practical management strategies and environmental regulations and how to find technical resources and financial help. Consult with local Cooperative State Research, Extension, and Education and NRCS offices for more information, access to the program, and technical support.

Concern for soil and water quality is the key to selecting a successful waste management plan, but criteria to be considered include the size of the operation, the economic consequences involved, and the growers' (and company's) personal management styles. The complexity of the system, whether it is dry or liquid, and the best management practices that can be used to minimize its effects on the environment are the subject of subsequent fact sheets in this series.

## Begin with the Land/Water Interface

Whether the wastes or by-products that accompany poultry growouts are good or bad for the environment depends in large part on interactions between the activities of the producers and the ecosystem. Hence, planning efforts begin with an assessment of the farmstead's location in relation to rivers, lakes, ponds, ditches and sinkholes; the chemical and physical properties of the soil profile; the availability of agricultural land in the production area; and the possible effects of poultry production on the naturally occurring cycles of nitrogen and phosphorus.

## Why Begin with Water

Agricultural activities, including — in some areas — mishandled or excessive poultry wastes, are a major source of nonpoint source pollution, although agriculture and forestry management are not the only sources. Crop production, pastures, rangeland, feedlots and other animal holding areas are agricultural sources of the U.S. waters assessed, 50 to 60 percent of the water quality problems in rivers and lakes and 34 percent of the waters in more urbanized coastal areas are impaired from agricultural sources. Bacteria, sedimentation, and nutrients are the leading pollutants.

Properly managing manure, controlling runoff, and nutrient management planning in conjunction with land applications will reduce or eliminate much of the proposed source of pollution and contribute to more productive farming. Most nonpoint source pollution problems can be controlled if growers know how nutrients and soil interact and plan accordingly.

Nitrogen, phosphorus, and potassium move through cycles on a farm. As nutrients, they go from crops to animals (in feed) to the soil (waste applications) and back again to other crops. If the cycle holds, everything works as it should. But too many nutrients already in the soil or too much waste applied to the land can move with the soil into surface water or through the soil into groundwater until their presence in the water reaches unacceptable levels, that is, is sufficient to impair water quality.

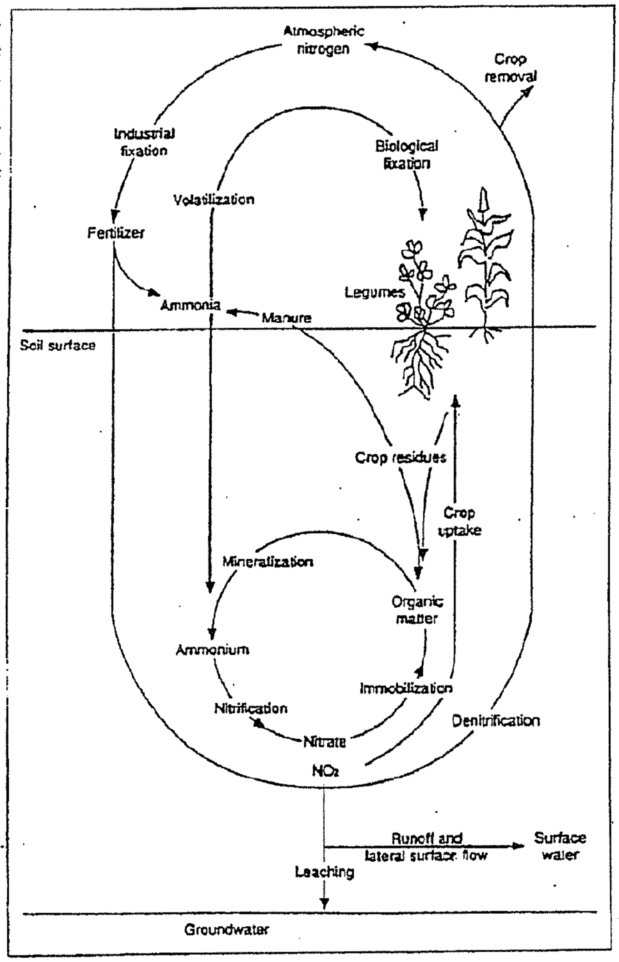


Figure 1.—The nitrogen cycle. Source: Pennsylvania State University, College of Agriculture. 1989. Groundwater and Agriculture in Pennsylvania. Circular 341. Reprinted with permission.

## Nitrogen

Of the three major nutrients in poultry waste, nitrogen is the most complex and hence the most likely to contribute to environmental problems. Most of earth's nitrogen exists as nitrogen gas in the atmosphere (see Fig. 1). It can be transformed into inorganic forms by lightning or into organic forms by plants, such as soybeans, alfalfa, or clovers. Nitrogen can also be transformed into inorganic forms (commercial fertilizers) by energy intensive processes.

Most of the nitrogen found in animal wastes is organic nitrogen. A smaller amount of the nitrogen in litter is ammonium. Organic nitrogen can be mineralized or converted by soil bacteria into inorganic nitrogen, the form in which nitrogen is available to plants. Excessive organic and ammonium forms of nitrogen will be transformed in soil into nitrate nitrogen (that is, into water soluble nitrogen).

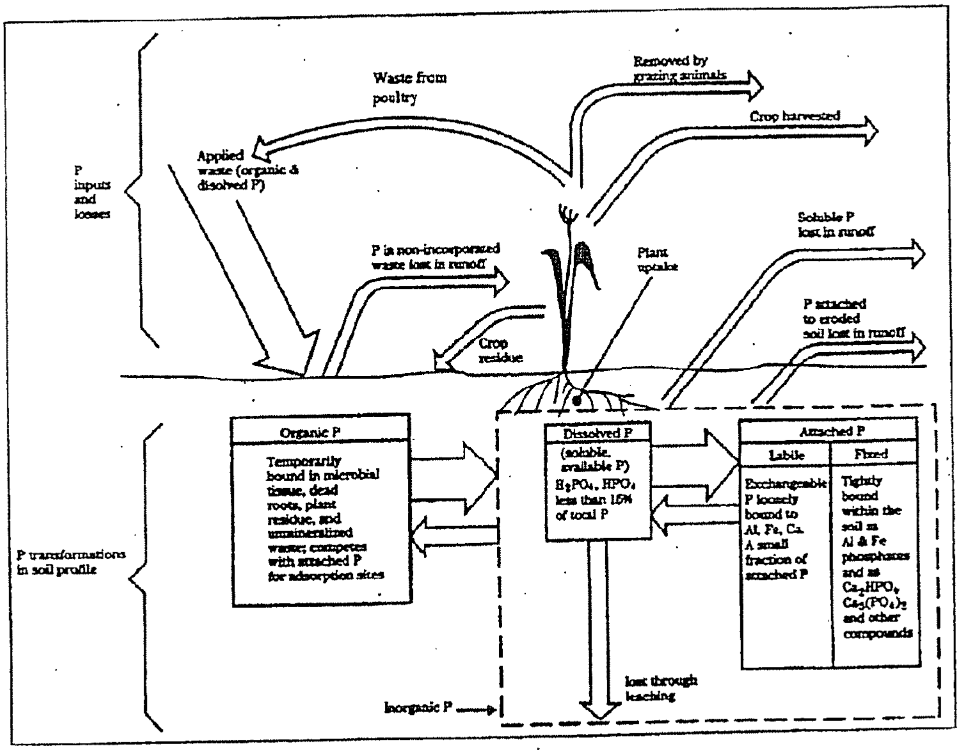


Figure 2.—Abbreviated phosphorus cycle.

Losses of nitrogen regardless of source (e.g., manure, commercial fertilizer, or municipal biosolids) from the cropping system can occur as a result of volatilization, surface runoff, and leaching. Surface runoff can move dissolved nitrogen (especially nitrate), ammonium nitrogen attached to eroding soil particles, and organic nitrogen contained in organic or plant residues into streams and lakes. Nitrates also move with the soil or leach through well-drained soils past the root zone into the groundwater supply.

High levels of nitrate can be toxic to human health, especially newborns. Nitrates reduce the blood's capacity to carry oxygen or cause internal suffocation. Scientists tell us that too much nitrate can affect the weight, feed conversion, and performance of poultry. Too much nitrogen in surface water makes the water less productive and may result in fish kills.

## Phosphorus

Poultry wastes also contain significant amounts of phosphorus (see Fig. 2). Phosphorus, like nitrogen, is essential for plant and animal growth and also contributes to environmental problems. In fact, it seems to be the limiting factor in the huge algae blooms that make lakes unfit for swimming and ultimately deplete their oxygen supply, deadening the water and killing fish. Phosphorus has become a major cause of water quality degradation.

Phosphorus exists in either dissolved or solid form. Dissolved phosphorus usually exists as orthophosphates, inorganic polyphosphates, and organic phosphorus in the soil. Phosphorus in the solid form is referred to as particulate phosphorus and may be composed of many chemical forms. Particulate phosphorus comes in four classifications:

- adsorbed phosphorus, which attaches to soil particles;

- organic phosphorus, which is found in dead and living materials;
- precipitate phosphorus, which is mainly fertilizer that has reacted with calcium, aluminum, and iron in the soil; and
- mineral phosphorus, the phosphorus in various soil minerals.

Approximately two-thirds of the total phosphorus in soil is inorganic phosphorus; the remaining one-third is organic. Both forms are involved in transformations that release water-soluble phosphorus (which can be used by plants) from solid forms, and vice versa.

Phosphorus-laden soil or dissolved phosphorus can move via runoff into rivers, lakes, and streams, where it causes excessive plant and algae growth, which in turn depletes the dissolved oxygen content in the water. Phosphorus-enriched waters contribute to fish kills and the premature aging of the waterbody. In the end, the beauty and use of the waters are seriously curtailed. Even relatively small soil losses may result in significant nutrient depositions in the water.

Controlling soil erosion and proper land application of phosphorus-containing wastes will greatly reduce the amount of phosphorus in water. While not normally a great concern, care must also be taken to prevent soluble phosphorus from leaching into groundwater.

Applying poultry waste to land at rates based on supplying the nitrogen needs of grain or cereal crops can lead to a phosphorus buildup in the soil. Planting forage crops in rotation with grain crops will help remove excess phosphorus. Maintaining soil pH at the recommended level is also an effective and economical practice for maximizing phosphorus efficiency. Crops use phosphorus most efficiently when the soil pH is between 6.0 and 7.0.

Soil phosphate levels are an important consideration in calculating poultry litter application rates. Land applications should be made only to soils that do not already contain excessive phosphate levels. An analysis or test should be conducted on each waste source prior to land application to determine proper phosphorus application rates.

### Potassium

Potassium in poultry waste is a soluble nutrient equivalent to fertilizer potassium. It is immediately available to plants when it is applied. Potassium is fairly mobile but does remain in the soil to help supply plant needs, for example, strong stems, resistance to disease, and the formation and transfer of starches, sugars, and oils. Excessive amounts of potassium can inhibit or restrict the growth of some plants at certain stages of development. Small amounts of potassium may be leached to groundwater, especially in sandy soils; however, potassium or potash is usually not a threat to water quality or considered a pollutant.

### Heavy Metals and Trace Elements

Heavy metals and trace elements, such as copper, selenium, nickel, lead, and zinc, are strongly adsorbed to clay soils or complexed (chelated) with soil organic matter, which reduces their potential for contaminating groundwater. However, excessive applications of organic waste containing high amounts of heavy metals or trace elements can exceed the adsorptive capacity of the soil and increase the potential for groundwater contamination. Excessive application of some heavy metals, for example, copper can be toxic to plants whose growth is needed to take up other nutrients.

Surface water contamination is a potential hazard if poultry wastes are applied to areas subject to a high rate of runoff or erosion.

### Salts

Dissolved salts, mainly sodium, in high concentrations interfere with plant growth and seed germination, and may limit the choice of plant species that can be successfully grown. Poultry waste with low salt content and a high carbon to nitrogen ratio can improve soil water intake, permeability, and structure.

### Using Litter Nutrients Wisely

High nitrate levels in groundwater and high phosphorus levels in surface water may be an indication that too much litter or fertilizer is being applied on too little land. Yet the fact that poultry litter is high in nutrients is precisely its value. The nutrients in this resource make it an excellent soil conditioner and fertilizer. Growers can maximize the benefits of having this resource and help protect their local water resources from high nutrient levels by planning and operating an effective nutrient management system.

Application practices will vary with the area's cropping practices, topography, and other environmental and economic conditions. Waste and soil testing are the simplest and most important aspects of nutrient management. They help farmers monitor the nutrient supply to guarantee that it is adequately controlled to produce the best crop yields and maintain water quality. When properly recycled, nutrients are not wastes but opportunities to improve the overall farming operation.

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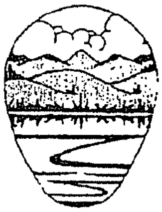


# Planning Poultry Waste Management

Poultry litter is a valuable by-product of the poultry industry. It is, for example, a natural soil amendment — a source of nutrients and organic matter that can increase soil tilth and fertility. If it is mishandled, it is also a potential pollutant of surface and groundwater.

Developments within the poultry industry and increasing restrictions or regulations on the disposal of poultry waste have significantly altered the industry's attitudes about this immense resource. Broiler operations alone produced over 15.2 billion pounds of litter in 1996, and because production is concentrated in very small geographic areas, waste management planning is extremely important.

Historically, poultry growers applied poultry waste to their farms as much to dispose of the material as to use it for fertilizer. Difficulties with this practice increase with the supply for several reasons:

- Less cropland is farmed than 20 years ago, and more poultry operations exist than in the past.
- Typically, more nutrients are brought onto the farm in the form of feed than leaves the farm in the form of meat or eggs. The nutrients left on the farm are in the manure and bird mortalities.
- Other resources (wastewater, composted residential waste, and sludge) are also being used for land applications, which increases competition for the remaining croplands and pastures.
- We know now that valuable nutrients — nitrogen, phosphorus, and potassium — are squandered and water resources are threatened if land applications of waste are overdone or misapplied.
- Regulations regarding waste management are now enforced by many states.

Increasingly, concern for water quality has become a major catalyst for the upsurge of interest in new approaches to land application. Today's growers are finding that they can no longer afford to dismiss the benefits of poultry waste planning, which include increases in farm production, environmental protection, and lower costs.

## Plan Components

The waste management system must provide for the collection, storage, and final distribution (use) of manure and dead birds in an environmentally safe way. State laws generally do not permit direct discharges of animal waste into water, and many states require permits for confined animal operations beyond a certain size. Soil and water quality considerations are the key to choosing among types of waste management systems (for example, whether to install a dry or liquid system).

Components will depend on the operation's size, operating plan, and the producer's access to technical expertise. For example, one facility may have an incinerator for handling dead birds; another may have an incinerator and a composting facility.

Components of waste management systems include, but are not limited to, the following:

- composting facilities;
- debris basins;
- dikes, diversions, and fencing;
- filter strips and grassed waterways;
- transportation and other heavy use area protections and equipment;

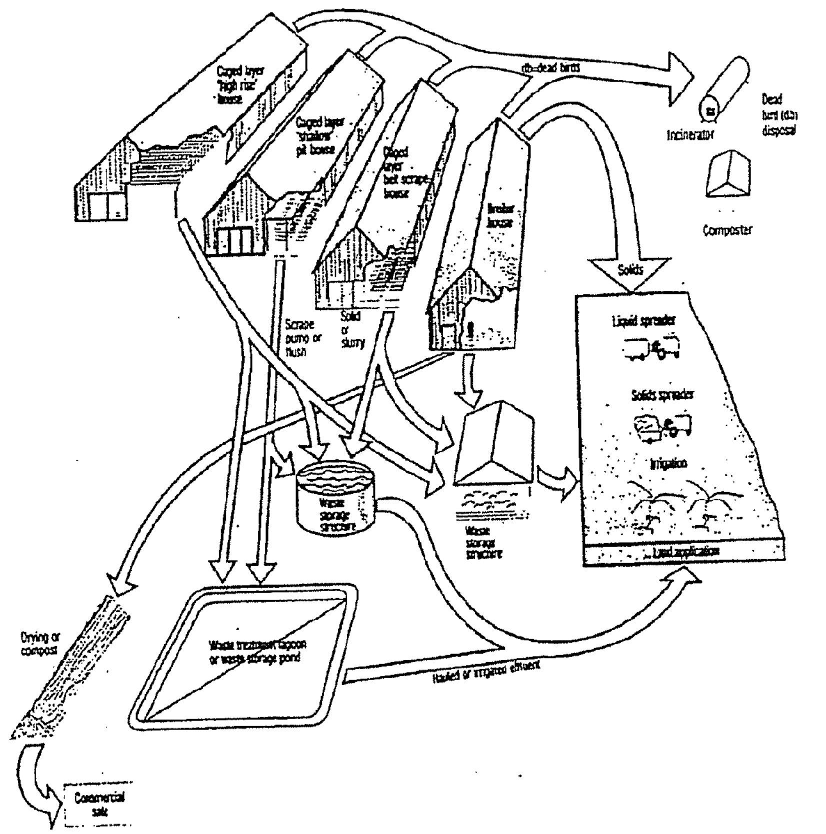


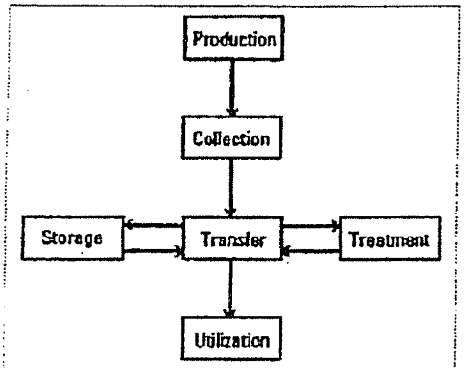

Figure 1.—Representative components of a poultry waste management system.

- irrigation schedules and equipment;
- nutrient management planning, including soil and manure testing procedures;
- pond sealings or linings;
- subsurface or surface drains, or both; and
- waste storage ponds, other storage structures, and treatment lagoons.

The relationship among these components is shown in Figure 1. Note that the drawing contains a broiler house and several examples of caged layer houses. Figure 2 shows the six stages of animal waste management.

## An Integrated Approach

Traditionally, poultry growers have efficiently disposed of litter as soon as possible by spreading the manure or litter on croplands or pasture. Now growers must begin their waste




For a specific system these functions may be combined, repeated, eliminated, or arranged as necessary.

Figure 2—Steps in an animal waste management planning system.

management inside the poultry house. Along with the objectives of flock health, production, and odor control, today's waste management planning must also protect water quality and contribute to a profitable farm operation. Integrating these broad objectives requires growers to develop other options in addition to land application.

Thus, to be profitable and to protect our natural resources — air, soil, water, plants, and animals — poultry growers must plan their waste management practices carefully. They must base application rates and timing on soil test results and crop removal needs along with an analysis or estimate of the nutrients contained in the manure or litter.

Poultry waste management planning begins before actual production and may have as many as six steps or functions (Fig. 2). The first step is to understand the waste management process. What are these wastes? How much does a particular operation produce on an annual basis? Where or how can these wastes be used? The second step, once the quantity and quality of the wastes have been determined, is to put efficient collection methods in place.

The third and fourth steps are to have adequate storage facilities and the ability to transfer or move the waste from the point of collection to the appropriate point of use. In some cases, a fifth step is included to determine whether biological, physical, or chemical treatment of the wastes is needed to reduce the potential for pollution or to prepare the wastes for final use.

The sixth and final step in the waste management plan is to use the wastes — normally, for land application as a fertilizer and soil improvement or as a feed ingredient — in accordance with the nutrient management plan. Growers will usually have identified sufficient land on which to apply the waste before production begins. If enough land does not exist, other uses must be assigned or additional lands located for disposal.

## The Benefits of Nutrient Management

Nutrient management actually begins when the poultry waste process has proceeded from collection and conservation to the actual use of these products for land applications or energy and feed production. Nutrient management planning matches the nutritional requirements of the soils, crops, or other living things with the nutrients available in the manure or litter, thereby preventing nutrient imbalances, health risks, and surface and groundwater contamination.

Nutrient value is based on the nitrogen, phosphorus, and potassium content of poultry waste. This value can be enhanced by matching the nutrients available in the resource with the nutrients needed in the application. This planning also reduces disposal and handling costs. Nutrient management planning makes it possible to use poultry manure to replace commercial fertilizers or at least to reduce their use — thereby reducing some costs of crop production. Nutrient management also minimizes the potential harmful effects that overapplication can have on the environment.

An essential goal of nutrient management is to make sure that any poultry waste, especially manure or litter, is used safely and effectively. Nutrient management is, in fact, the key to using this waste as a beneficial by-product. To obtain maximum benefit and prevent possible contamination of surface and groundwater, the following management principles and practices can be applied:

- Develop and apply a Resource Management System, an Animal Waste Management System, a Nutrient Management Plan, or similar program. Assistance is available from the local offices of the U.S. Department of Agriculture's Natural Resources Conservation Service, the Cooperative State Research, Extension, and Education Service, state departments of agriculture, or soil and water conservation districts.

- Find out if your state uses nitrogen as a basis for land application requirements. If not, is phosphorus a concern in your area?
- Analyze poultry waste regularly to monitor major nutrients and pH levels. Proper soil pH will help maximize crop yields, increase nutrient use, and promote decomposition of organic matter.
- Apply only as much fertilizer (nutrients) as the crop can use.
- Calibrate equipment and apply waste uniformly.
- Incorporate poultry waste into the soil if possible to reduce runoff, volatilization, and odor problems.
- Do not spread poultry waste on soils that are frozen or subject to flooding, erosion, or rapid runoff prior to crop use.
- Spread poultry waste during specific growing seasons or as scheduled for maximum plant uptake and to minimize runoff and leaching.
- Use proper storage methods prior to land application.
- Maintain a vegetative buffer zone between the field of application and adjacent streams, ponds, lakes, sinkholes, and wells.
- Follow approved conservation practices in all fields.
- Be considerate of neighbors and minimize conflicts when transporting or land applying poultry waste.

Training, technical assistance, and in some cases, financial aid are available to help growers and crop farmers identify problems and develop solutions for using poultry waste in their specific regions. The Natural Resources Conservation Service and Cooperative Extension Service have developed work sheets for animal waste management systems that help growers estimate production, obtain soil and manure analyses, and make economical and practical use of the organic resources generated on the farm. These agencies and others can help growers design facilities and develop overall resource management plans.

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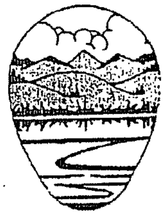


# DRY WASTE MANAGEMENT

A well-planned waste management system will account for all wastes associated with a poultry agricultural enterprise throughout the year, from the production of such wastes to their ultimate use. The more integrated the waste management system is with the grower's other management needs, such as production, marketing, pest control, and conservation, the more profitable the farm will be.

The best method for managing poultry manure depends on the type of growing system (open range or enclosed housing), dry or liquid collection, and the way the house is operated. Misuse of poultry manure can reduce productivity; cause flies, odor, and aesthetic problems; and pollute surface and groundwater. Poultry manure can produce dust and release harmful gases such as carbon dioxide, hydrogen sulfide, methane, and ammonia. Fresh manure is troublesome if it gets too wet.

Poultry wastes are handled differently depending on their consistency, which may be liquid, slurry, semisolid, or solid. The total solids concentration of manure depends on the climate, weather, amount of water consumed by the birds, type of birds produced, and their feed; it can be increased by adding litter or decreased by adding water.

Within the poultry industry, broiler, roaster, Cornish hen, pullets, turkey, and some layer operations are dry; live bird processing, some layer, and most duck and goose operations are liquid. In most dry operations, the birds are grown on floors covered with bedding materials. The manure collected from ducks, geese, and large high-rise layer operations is usually pure or raw manure, unmixed with litter though it may be mixed with water during cleanout.

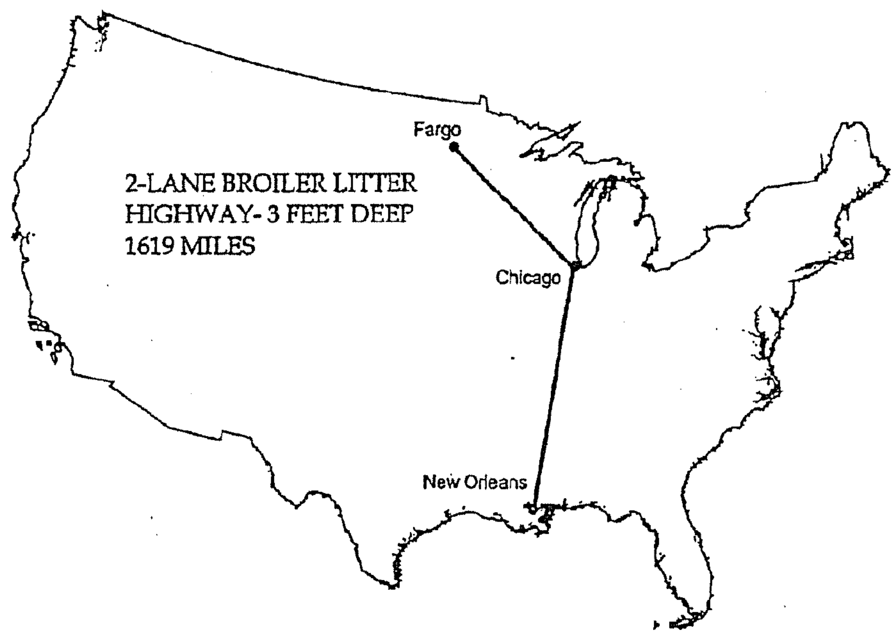
## Open Range or Enclosed Housing

Fields, pastures, yards, or other outdoor areas are used as ranges for chickens, turkeys, ducks, or game birds. Such areas must be located and fenced so that manure-laden runoff does not enter surface water, sinkholes, or wells. Unless these areas are actually feed lots (confinement areas that do not support vegetation), no collection and storage of manure is required. Instead, the manure is recycled directly to the land. Best management practices, such as pasturing the animals away from sinkholes and other water resources, and preventing animal access to streams, apply to these operations. In confinement operations, by contrast, the manure is collectible and can become a valuable coproduct of the operation.

In enclosed settings, dry and liquid wastes require different collection, storage, handling, and management systems. The management of dry manure depends primarily on how it is stockpiled or stored from the time of its production (at cleanout) until it is properly land applied. The following paragraphs describe general house conditions that affect the production and quality of this material and the principles of dry waste management. Liquid waste management is explained in an additional fact sheet contained in this handbook (PWM-4).

## Kinds of Poultry Waste — Manure and Litter

Livestock manure is feces and urine; poultry waste is manure with added bedding or water. The only way to know for certain its quantity, concentration and composition is from lab analysis. The amount of manure a given flock produces can be estimated from the amount of feed the birds eat. Roughly 20 percent of the feed consumed by poultry is converted to manure. Manure mixed with a




1996 BROILER PRODUCTION = 7,598,200,000 (NASS, April 1997)
LITTER GENERATED = 2lbs/Broiler/Year

Figure 1.—The broiler litter highway: broiler litter generated in 1996, in the United States.

water. The only way to know for certain its quantity, concentration and composition is from lab analysis. The amount of manure a given flock produces can be estimated from the amount of feed the birds eat. Roughly 20 percent of the feed consumed by poultry is converted to manure. Manure mixed with a bedding material is called litter, and its constituent properties vary, depending on how the chickens are fed and their age and size.

Other conditions that affect litter's quality include the age and type of the bedding material, excessive moisture, frequency of cleanouts, and subsequent storage conditions. The constituents of the litter can be estimated from prior analyses of similar wastes, but all litter should be analyzed at least once a year until its nutrient value is firmly established (after that, it may be tested less frequently, perhaps every two or three years unless management practices change).

The volume of litter varies widely, depending on the producer's management style. Indeed, many of the same conditions that determine the litter's makeup also affect its quantity. For example, the feedstock, number of cleanouts, climatic conditions, and bird genetics are all factors. Broilers, however, produce as much as two pounds of litter per bird or about one ton per year per 1,000 birds: about 81 cubic feet of litter for each 1,000 birds.

In 1996, nearly 15.2 billion pounds of litter were produced by broiler operations in the United States — enough to cover 1,619 miles of a two-lane highway to a depth of three feet. This estimate is from the USDA National Agricultural Statistics Service, and the "litter highway" can be imagined as the distance from New Orleans, Louisiana, to Chicago, Illinois, and on to Fargo, North Dakota (Fig. 1).

That much litter can and must be responsibly used. Bedding materials, manure, and used erals in broiler litter include calcium, magnesium, sulfur, sodium, iron, manganese, zinc, and copper.

| Table 1.— | |
|---|---|
| LITTER PRODUCED PER 1,000 BIRDS | |
| 2 lb bird | 0.45 ton per cycle |
| 4 lb bird | 1.0 ton per cycle |
| 6 lb bird | 1.5 ton per cycle |
| AVERAGE NUTRIENT CONTENT OF BROILER LITTER | |
| nitrogen | 60 lb per ton |
| $P_2O_5$ | 55 lb per ton |
| $K_2O$ | 45 lb per ton |

## Management Practices

Litter should be kept from becoming overly wet. In a well-managed house, the moisture level in litter will range from 25 to 35 percent. Higher moisture levels increase its weight and reduce its nitrogen value. Litter that does not become saturated can be left in the house between flocks. However, cake (litter that is saturated with water) must be removed from the house between cleanouts to protect the remaining litter. After its removal, the cake should be dried to prevent odor, precautions should be taken to prevent groundwater contamination, and stormwater should be diverted from contact with the litter.

If cake is properly removed from the house, total cleanouts can be delayed — sometimes for an entire year. Checking for water leaks in the house and keeping the house at an even temperature are management practices that reduce the production of cake. The total weight and volume of litter will depend on the type of bedding material used, its depth, whether cake is present or removed, and the length of time between cleanouts. Its quality also depends on how it is removed from the house, whether the floor is raked or stirred between flocks, and how it is stored.

Manure is dried by aerating it using some form of ventilation. Ventilation can be achieved naturally (through proper housing design) or mechanically (through equipment). Aeration should produce a low odor product with about 15 to 25 percent moisture. Because it has less odor and weight, it is less expensive to haul, contains more nutrients, and is easier to store.

## Dry Waste Storage Facilities

Common procedures for managing dry broiler litter or dry manure from layer operations center on protecting this material after it is removed from the house until its valuable fertilizer nutrients can be put to other uses. Litter that is not properly stockpiled or stored suffers a reduction of nitrogen from releases to air and water. These losses represent both lost income and the potential for surface and groundwater contamination. To prevent such losses, facilities used for storing dry poultry waste should meet or exceed the following conditions:

- a sufficient capacity to hold the waste until it can be applied to land or transported off the farm,
- adequate conditions of temperature and humidity to permit storage of the waste until it is needed,
- a concrete or impermeable clay base to prevent leaching to groundwater,
- appropriate roofing, flooring, and drainage to present rainfall, stormwater, runoff, and surface or groundwater from entering the waste,
- a location that prevents runoff to surface waters or percolation to groundwater, and
- ventilation and containment for effective air quality and nuisance control.

The ideal storage design is a roofed structure with an impermeable earthen or concrete floor. This design keeps the litter dry, uniform in quality, and easy to handle, and it also minimizes fly and odor problems. Management plans that allow for proper storage achieve the following:

- save water,
- improve bird quality,
- improve the production environment,
- reduce the amount of ammonia released from litter,
- reduce the volume of cake,

- extend the time between cleanouts,
- increase the product's value and flexibility, and
- protect the quality of adjoining waters.

## Kinds of Storage Facilities

Generally, storage facilities can be open, covered, or lined (permanently lined, in some cases); or they can be bunkers or open-sided buildings with roofs. Perhaps the most common facilities for collecting and storing poultry litter include floors, pits, dry-stack buildings, or covered outdoor storage facilities with impermeable earthen or concrete flooring.

## Floor Storage

Most broiler, roaster, Cornish hen, pullet, turkey, and small layer operations raise birds on earthen or concrete floors covered with bedding material (Fig. 1). A layer of wood shavings, sawdust, chopped straw, peanut or rice hulls, or other suitable bedding material is used as a base before birds are housed. Wet litter — that is, cake — is removed after each flock. A complete clean-out can be done after each flock or once every 12 months or longer, depending on the producer's requirements. Slat or wire floor housing, used mainly for breeder flocks, can be handled the same way. Floor storage is the most economical method to store litter. Care must be taken not to leave foreign material such as wire, string, light bulbs, plastic, or screws in the litter.

## Dry Stack Storage

Temporary storage of litter in a roofed structure with a compacted earthen or concrete floor is an ideal management method (Fig. 2). Large quantities of waste can be stored and kept dry for long periods of time. To prevent excessive heating or spontaneous combustion of wastes, stacks should not exceed 5 to 8 feet and large variations in moisture content should be avoided. Dry stacks promote ease of handling and uniformity of material; in addition, disposal is relatively easy. Dry stacks protect the resource from bad weather and make it available for distribution at appropriate times.

A variation on this option is a stack or windrow located in an open, well-drained area and protected from stormwater runoff. The stack must be covered with a well-secured tarpaulin or other synthetic sheeting.

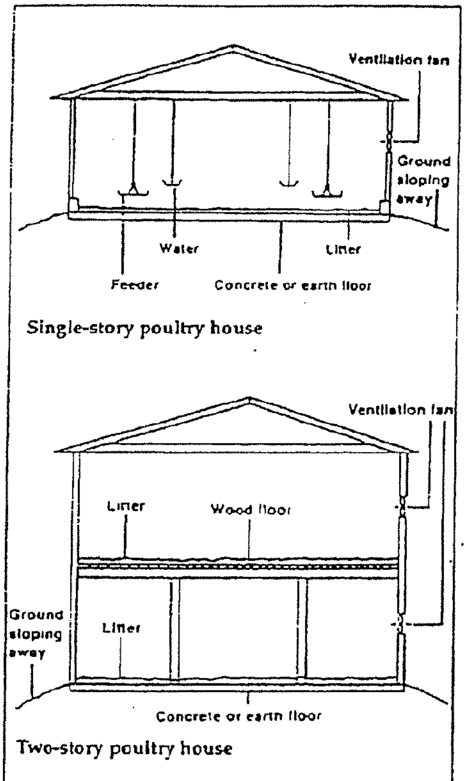



Figure 1.—Two types of litter-floor poultry houses.

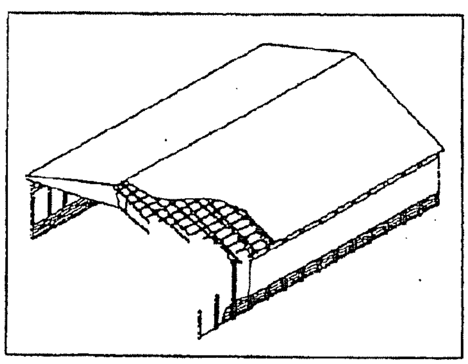


Figure 2.—An ideal dry stack storage facility is a roofed structure with an earthen or concrete floor.

Storage in covered or uncovered facilities is not the only alternative. Field storage on the farm, applicator storage (that is, storage by the crop farmer who will use the litter or manure for fertilizer), cooperative storage (several growers sharing a larger facility off-site), and private storage (by entrepreneurs who will sell or process the litter to create new products) are additional methods of waste storage. Each method must be evaluated in terms of cost, environmental safety, and industry and regulatory practice.

In some states, permits may be required for a storage facility or for other parts of your resource management system. Possible zoning restrictions may also influence your choice of storage systems.

Proper storage is essential to optimize the waste's fertilizer value for crops, provide ease of handling, and avoid groundwater or surface water contamination. Consider also the feasibility of processing alternatives. Waste can be

- composted and pelletized to produce soil amendment and fertilizer products,
- converted to feed for beef cattle or to briquettes for fuel, or
- deposited in lagoons for anaerobic digestion and methane production.

Above all, use soil and manure testing to improve the success (crop yields) and timing of land applications. Practice biosecurity (that is, safeguard the application from disease causing organisms and fly larvae) at all times.

Using poultry litter as a feed supplement for cattle has become popular. Methods of waste handling and storage can greatly affect the quality of the material as a feed ingredient. Litter with the highest nutritional value for refeeding is found in the upper layers of the litter pack. Large amounts of soil increase the ash content and reduce the nutritive value of litter. Feed litter should be deep stacked at least three weeks to ensure that sufficient heat is generated to kill pathogens.

Remember: The use of manure storage structures is a best management practice for the protection of environmental quality, and an interim step in waste management planning. It should be followed by nutrient management planning and appropriate use of the litter for land application.

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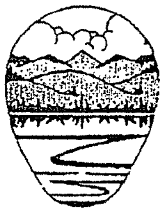

# Liquid Waste Management

Ducks, geese, and some layer operations are usually handled through liquid waste management systems, though water greatly increases the amount of waste to be processed. In liquid waste management systems, collection and storage are generally combined in one operation, and in facilities that include pits, settling tanks, and earthen storage ponds, or lagoons. Sometimes additional treatment is used to convert its nutrient and mineral content to more stable products.

Volume comparisons between liquid and dry manure show that 10,000 caged layers produce nearly 2,500 pounds of manure per day, with an estimated volume of 50 cubic feet. In dry form, this manure weighs about 695 pounds, with 10 percent moisture, and reaches a volume of 27 cubic feet. This difference notwithstanding, liquid waste management systems can be easier to automate and less labor intensive than dry waste management.

Constraints on the management system appear to be greater when the system is liquid:

- the pond or other holding facility must be emptied immediately when it is filled — the grower has less flexibility for scheduling land applications;
- if the waste storage structure is not properly designed and sealed, its contents may leach to groundwater or overflow into ditches, agricultural drains, or other surface water resources;
- toxic gases or unpleasant odors can occur in liquid waste, particularly when it is agitated or stirred;
- flies may find the manure storage ponds attractive breeding grounds, especially if they are improperly managed; and — a more important consideration —
- nearly all states have clean water laws that prohibit wastewater discharges to surface waters and groundwater recharge areas. Therefore, nearly all animal operations that have a liquid waste management system must have formal or informal permits to comply with these laws, even if they are not required to file for federal National Pollution Elimination Discharge System permits.

By contrast, solid waste systems are perceived to have less environmental risks; and with less volume to control, they may also have lower equipment and energy costs. These considerations — and operator preference — may help growers decide between dry and liquid waste management systems.

Lagoon flush systems were a source of environmental and public relations problems (e.g., spills and odors) during heavy rains in 1995 and 1996. If such problems persist, growers and researchers are likely to combine the best features of liquid and dry systems to find more protective and efficient methods of waste management. Researchers in Georgia have already modified a flush-type system beneath a caged layer line to accommodate a deep litter composting system. Plywood boxes containing plywood shavings are placed under the cages to collect the manure, which is turned twice weekly to promote composting.

## Liquid Collection Methods — Pit Storage

Layers or pullets are often raised in cages arranged in two to four decks. The manure falls directly into a pit or is scraped into the pit from intervening dropping boards. Pits must be cleaned regularly, and the manure stored in concrete or steel storage tanks or applied directly to the land. A lagoon may be necessary to catch overflow. Ventilation fans are essential to keep the manure dry, and reduce toxic gases, fly problems, and offensive odors.

There are three basic pit designs:

▼ **Shallow-pit systems**, built of concrete at ground level, are 4 to 8 inches deep and located 3 to 6 feet below the cages. Manure is scraped from the pit or flushed out with water and collected in a storage area or loaded directly into a spreader (Fig. 1).

▼ **Deep-pit systems** are usually 4 to 8 feet wide and may extend 2 to 6 feet below ground level with the cages at least 8 feet above the concrete or masonry floor. The pit floor and sidewalls must be sealed and thoroughly protected from stormwater runoff and groundwater seepage. Foundation drains and external grading are needed to remove subsurface water and to drain surface water away from the building.

▼ **High-rise systems** are similar to deep-pit systems but are built entirely aboveground. The cages are 15 to 30 feet above the ground (Fig. 2). The pit floor should be concrete and graded, with foundation drains. The water supply must be controlled if the wastes are retained in place for extended periods. If outside water penetrates the system and breaks out the side board, the manure can develop a serious fly problem or leach nutrients to groundwater.

## Settling Tanks

Concrete, concrete block, or steel storage tanks can be used to collect solids and to skim floating material from a layer operation. A floating baffle or other separator can be installed to remove egg shells, feathers, and other debris. The tank should be placed between the layer house and a waste storage pond or lagoon. Normally, a settling tank is 4 feet at the deep end, sloping to ground level. Walls are slotted to allow drainage of the settled waste.

It is recommended that two settling tanks be installed; one can be drained and cleaned while the other remains in operation. The tanks must be properly constructed and sealed to prevent groundwater or surface water pollution. In tanks and storage ponds, unpleasant odors and dangerous gases may be present and may require protective measures.

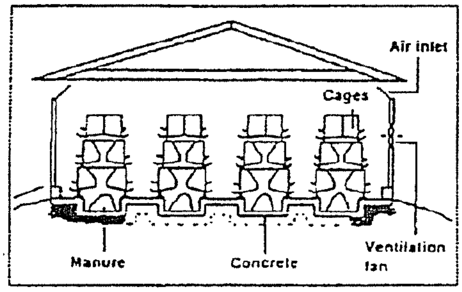


Figure 1.—Shallow-pit poultry house with cages.

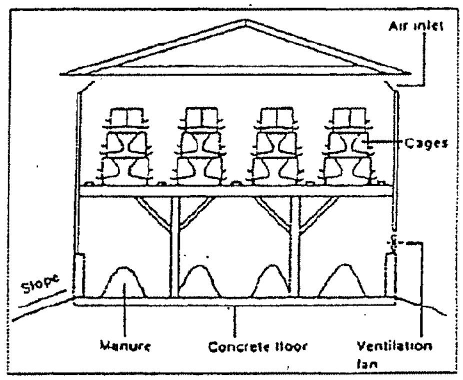


Figure 2.—High-rise poultry house with cages.

## Treatment Lagoons and Ponds

Semisolid or liquid manure can be removed from the pits (by flushing or scraping) and stored in below- or aboveground storage tanks, steel storage tanks, or holding ponds. Lagoons, a type of earthen storage basin, have a manure treatment function in addition to a storage function. Lagoons use anaerobic or aerobic bacteria to decompose the waste, and they can even be used as digesters to convert large masses of waste into gases, liquids, or sludge.

Lagoons are easy to manage, convenient, and cost-efficient. Storage and land application can be handled more opportunely if the grower has a lagoon, and labor costs and operating costs are slight after the initial investment. Such facilities became a somewhat popular component of waste management systems during the 1970s when the interest shifted from simply using waste for fertilizer in land applications to treating the waste to produce a more convenient waste management system overall (with less organic content to land apply).

The decomposition process will be anaerobic or aerobic. Anaerobic bacteria in animal waste (i.e., bacteria that live in animal intestines) cannot work in the presence of oxygen. Aerobic bacteria, on the other hand, must have oxygen; therefore, anaerobic lagoons are deep and airless; aerobic lagoons are spread over a large surface area, take in oxygen from the air, and support algae. Both aerobic and anaerobic lagoons provide storage and disposal flexibility.

Other factors, however, must also be considered. Anaerobic lagoons are a source of odors and nitrogen losses and may require frequent sludge removal if they are undersized. Groundwater protection may be difficult to secure in either system. If mechanical aeration is used for an aerobic system, energy costs must be included in the accounting. Proper management is essential for lagoon maintenance and operation.

### Aerobic Lagoons

The design, shape, size, capacity, location, and construction of the lagoon depends on its type. Aerobic lagoons require so much surface area (to maintain sufficient dissolved oxygen) that they are an impractical solution to most waste management problems. They may require 25 times more surface area and 10 times more volume than an anaerobic lagoon. Nevertheless, some growers may consider using an aerated lagoon — despite its expense — if they are operating in an area highly sensitive to odor.

Some of the sizing difficulty can be solved by using mechanical aeration — by pumping air into the lagoon — but the energy costs for continuous aeration can be high. Aerobic lagoons will have better odor control, and the bacterial digestion they provide will be more complete than the digestion in anaerobic lagoons.

Lagoon design and loading specifications should be carefully followed and monitored to increase the effectiveness of the treatment. No more than 44 pounds of biological oxygen demand (BOD) should be added to the lagoon per day per acre. The lagoon should have sufficient depth so that light will penetrate the 3 or 4 feet of water. Effluents from the lagoon should be land applied to avoid long-term ponding and to make economical use of the nutrients that remain in them.

### Anaerobic Lagoons

Anaerobic treatment lagoons are earthen basins or ponds containing diluted manure that will be broken down or decomposed without free oxygen. In the process, the organic components or BOD in the manure will be liquified or degraded naturally.

Anaerobic lagoons must be properly designed, sized, and managed to be an acceptable animal waste treatment facility.

Liquid volume rather than area determines the size of anaerobic lagoons. The lagoon should accommodate the design treatment liquid capacity and the amount of wastewater to be treated; it should also have additional storage room for sludge buildup, temporary storage room for rain and wastewater inputs, extra surface storage for a 25-year, 24-hour storm event, and at least an additional foot of freeboard to prevent overflows.

The design criteria for anaerobic lagoons are based on the amount of volatile solids to be loaded each day. The range is from 2.8 to 7.0 pounds of volatile solids per day per 1,000 cubic feet of lagoon liquid. The amount of rain that would collect in a 24-hour storm so intense that its probability of happening is once in 25 years requires at least 5 to 9 inches of surface storage, although the actual volume of surface storage required is site specific.

To protect the groundwater supply, lagoons should not be situated on permeable soils that will not seal, on shallow soils, or over fractured rock. The bottom of the lagoon should not be below the water table. Nor should mortalities be disposed of in lagoons. In fact, screening the wastes before they enter the lagoon helps ensure complete digestion and the quality of the wastewaters for land applications. If the site's topography indicates a potential for groundwater contamination, then any earthen basin should be lined with clay, concrete, or a synthetic liner.

New lagoons should be filled one-half full with wastewater before waste loading begins. Planning start up in warm weather and seeding the bottom with sludge from another lagoon helps to establish the bacterial population. Because bacterial activities increase in high temperatures, lagoons, in general, work best in warm climates. Manure should be added to anaerobic lagoons daily, and irrigation (drawdown) should begin when the liquid reaches normal wastewater maximum capacity. The liquid should not be pumped below the design level treatment, however, because the proper volume must be available for optimum bacterial digestion.

Drawdown (that is, the lagoon liquid) can be used for land applications guided by regular nutrient management planning and sampling of the lagoon liquids and soils to ensure safe and effective applications. When sludge accumulation diminishes the lagoon's treatment capacity, it, too, can be land applied under strictly monitored conditions.

Secondary lagoons are often needed for storage from the primary lagoon. Using a secondary lagoon for irrigation also bypasses some of the solids picked up in the primary lagoon. The size of secondary lagoons is not critical.

Information and technical assistance and some cost-share programs are available for producers who determine that a lagoon system should be part of their resource management system. The USDA Natural Resources Conservation Service (NRCS) and the Cooperative State Research, Extension, and Education Service offices can provide additional assistance.

## Land Applications

Land application of liquid waste can be achieved with a manure slurry or irrigation system. If the application falls directly on the crop, care must be taken to prevent ammonium toxicity and burning. Because raw manure contains high amounts of uric acid, it should be thoroughly mixed before application. Layer lagoon sludge is more dense than a pullet lagoon sludge because of its high grit or limestone content and should be diluted before application.

Timing is a major factor in successful land applications. There should be no land application prior to, during, or immediately following a rainfall event. The manure must also be uniformly applied — whether you are using a manure spreader or an irrigation system. The operator should be particularly careful (especially during a drought) not to coat the plants with lagoon liquid. Instead, make several small applications of lagoon liquid, rather than one large one.

Liquid waste is primarily disposed of through land applications. Proper spreading on the land is an environmentally acceptable method of managing waste. However, with increasing environmental concerns and the need to match closely the fertilizer needs of crops, farmers can no longer afford to simply "spread manure."

The USDA NRCS, Cooperative State Research, Extension and Education Service, and other agencies offer poultry waste and nutrient management planning assistance. These offices have worksheets to help growers plan liquid waste management, which includes the following tasks:

- determining the amount and volume of waste generated;
- calculating land application requirements;
- sampling and analyzing the nutrient composition in poultry litter, manure, or slurry; and
- matching the nutrients available in these products with crop nutrient requirements for land applications.

Detailed information on how to prepare nutrient assessments, conduct soil testing, and calculate application rates, timing, and methods of application are also available from these agencies.

The use of nutrient management planning will help growers make economical and practical use of the organic resources generated on their farms.

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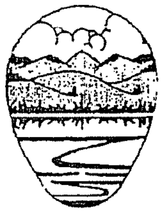

# Composting Waste Products

Poultry litter or layer manure is most often land applied to pastures and crops for its value as an organic fertilizer. We know from long experience how beneficial this practice can be when soil and manure nutrient testing are integrated with crop nutrient needs to determine the amount and timing of the application. This integration makes it possible to approach land application as a wise use of resources rather than as a disposal method.

Proper storage and treatment of poultry by-products (litter, manure, hatchery waste, and dissolved air flotation [DAF] skimmings) before use are important to minimize compositional changes and decrease odor and handling problems. Depending on the by-product, dry storage, ensiling, or composting may be appropriate treatments. Resource management systems may include incineration and burial as methods of disposal; however, these techniques are not called treatments because they do not usually provide any reusable products.

Composting is an environmentally sound and productive way to treat poultry by-products and mortalities (see also PMM/4 and PMM/5). The product of composting is easier to handle, has a smaller volume, and is a more stable product than the raw materials. The nutrient content of the compost will be nearly the same as the starting materials if the composting is performed properly.

While compost can be land applied to decrease the need for nutrients from commercial fertilizers, composted by-products may also be marketed for higher value uses on turf, for horticultural plant production, and in home gardening landscaping. It can be added as an amendment to soils for transplanting flowers, trees, and shrubs, or to establish new lawns. Compared to commercial fertilizers, poultry by-product compost will have a lower nutrient analysis (e.g., 2-2-2) for nitrogen, phosphorus, and potassium. However, there are other benefits to the soil and plant growth associated with the organic matter and micronutrients in compost.

## Understanding the Process and Benefits of Composting

Composting is a natural, aerobic, microbiological process in which carbon dioxide, water, and heat are released from organic wastes to produce a stable material. Leaves and other organic debris are subject to this process all the time — that is, the activity of microorganisms transforms these materials into a soil-like, humus-rich product.

This natural process can also be used as a resource management technique to transform large quantities of litter, manure, and other poultry by-products into compost. The conditions under which natural composting occurs can be stimulated and controlled so that the materials compost faster and the nutrient value of the compost is maximized.

The composting process is relatively simple:

1. By-products, for example, litter, manure, eggshells, hatchery waste, and DAF skimmings, are placed in bins, piles, or elongated piles called windrows. A bulking agent or carbon amendment (e.g., sawdust, wood chips, yard waste, or paper that is rich in carbon but low in other nutrients) is usually necessary to provide the proper ratio of carbon to nitrogen in the mix and to improve aeration.

2. Air is needed to support and enhance microbial activity. Because the composting microorganisms are aerobic, that is, oxygen using, the windrows and compost piles must be aerated to ensure the

efficiency of the process. Sufficient aeration also minimizes the formation of objectionable odors that form under anaerobic (oxygen depleted) conditions. Adequate aeration can be provided by forced air systems, such as blowers or fans; or by turning the compost with a front-end loader or a commercially available compost turner as required.

3. Mechanical agitation or turning of the materials supplies aeration, helps mix the materials, and distributes any added water.

4. Temperatures in the compost must be maintained at levels above approximately 130°F to kill any pathogens (disease-causing organisms) and promote efficient composting. Temperatures above 150 to 160°F should be avoided because they reduce the microorganisms that are beneficial to the composting process.

5. Adequate moisture, between 50 and 60 percent, is necessary for optimal microbial activity.

## Handling Compost

Compost produced from poultry by-products can be used in many different ways: it can be used directly as a soil amendment for agricultural or horticultural uses; pelletized or granulated for ease of transportation and application; or enhanced with conventional fertilizers to improve its nutrient value.

Even though composting is a relatively new manure management technology, the off-farm market is clearly growing. Consumer awareness of the safety and convenience of the product is beginning to penetrate the market. Current limiting factors are growers' unfamiliarity with marketing strategies and competition from less costly products.

## Possible Drawbacks

Composting, like any management technique, cannot be undertaken lightly, whatever its benefits. It requires a commitment of time and money for equipment, land, storage facilities, labor, and management. Composting is an inexact process that depends heavily on the quality and characteristics of the materials being composted and the attention given to the composting process.

Although the finished product should have no odor or pest problems, such problems may occur during the composting process. Weather may also affect the process adversely. Compost releases nutrients slowly — as little as 15 percent of the nitrogen in compost may be available during the first year of application. In addition, costs associated with production-scale composting can be significant, and federal and state regulations for stormwater runoff from the composting site must be followed.

Despite these potential drawbacks, composting on the farm is a practical resource management technique. Good management will consider every opportunity to eliminate or reduce the concerns associated with composting while maximizing its benefits. Once it is realized that composting can be more than a "dump it out back and forget it" procedure, the technique can be used and adjusted to meet by-product management needs.

## Composting Methods

There are four general methods of composting: passive composting, windrows, aerated piles, and in-vessel composting.

▼ **Passive composting** is the simplest, lowest cost method. It requires little or no management because the materials to be composted are simply stacked into piles and left to decompose naturally over a long time.

Passive composting is not suitable for the large quantities of litter or manure produced on poultry farms. It occurs at comparatively low temperatures and decomposition occurs at a slow rate. Anaerobic conditions resulting from insufficient aeration can result in objectionable odors.

▼ **Windrow composting** occurs in long narrow piles that can vary in height and width depending on the materials and equipment available for turning.

For most efficient composting, windrows are turned as required depending on temperature and oxygen measurements.